AN INVESTIGATION ON THE GROUND WATER CONTAMINATION :
A CASE STUDY OF ALIGAON, NEAR BADARPUR THERMAL POWER STATION, NEW DELHI

Dissertation submitted to the Jawaharlal Nehru University
in partial fulfilment of the requirements
for the award of the degree of

MASTER OF PHILOSOPHY

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July, 1987

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DEDICATED TO MY PARENTS

CERTIFICATE

This dissertation entitled "AN INVESTIGATION ON THE GROUND WATER CONTAMINATION: A CASE STUDY OF ALI GAON NEAR BADARPUR THERMAL POWER STATION, NEW DELHI" has been carried out at the School of Environmental Sciences, Jawaharlal Nehru University, New Delhi. The work is original and has not been submitted in part or full for any other degree or diploma of any university.

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Anwar Hussain

(ANWAR HUSSAIN)

CONTENTS

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A VIEW OF ALIGAON.

A VIEW OF BTPS.

INTRODUCTION

INTRODUCTION

Water is one of the most valuable and sine qua non natural resources of the earth. One can not imagine life without water. Life itself is a product of water. Though the Hydrosphere contstitutes a major part of the Biosphere, the water suitable for agricultural, industrial and civic purposes is limited. From the view points of potability and hygiene, the available water is scarce and unevenly distributed.

The oceans occupy 79% area of the globe and contain 97% of the available water (Wetzel, 1982) but that is saline. The remaining water is fresh but 75% of this is locked up in the ice caps and ice sheets and thus is non-available. Only a little part of the freshwater is available (Wetzel, 1982). 90% of this in buried beneath the surface and called ground water (Scalf et al, 1981).

In many cases the ground water is more or less a renewable resource (Dakshinamurti et al 1973) and thus holds great promises for the everburgeoning pupulation of the world. Ground water has been used for drinking and irrigation purposes since the time immemorial. With the advancement of digging/drilling technology the groundwater is now being exploited in large scales to feed the urban water supply schemes and meet the irrigation requirements.

India exploits 17.37 million-hectare-metre groundwater for various purposes(Central ground water board report 1982) along with irrigation of 27.5 hactare land (Row, 1969 and - C.G.W. Board, 1980) High priority has been accorded to the ground water resources development in subsequent plans and it is in this context that the groundwater management and its quality maintenance assume great significance (Row, 1969).

India is fortunate to have vast reserve of groundwater i.e. 3700 million-hectare-metre (Khosla) 1949),(Dakshinmurthy et.al. 1974 - 1969) which is ten times the annual rainfall of the country. Approximately one tenth of the annual rainfall i.e. 27 million-hectare-metre is consumed in recharging the groundwater aquifers every year. This is above the present level of exploitation of the ground water.

With the population explosion and ever expanding and diversifying economic activities of humankind, environment is under rentless onslaught Unscrupulous tampering with the ecosystem has led to the degradation of the quality of environment in terms of hospitability and aestheticity in general. The aquatic system is more susceptible to the anthropogenic activities. The indiscriminate disposal of municipal waste and industrial effluents along with the agricultural run off in water bodies have polluted the water system and rendered them usless,the great Indian rivers are the glaring examples of pullution. The pristine pure water emanating from the glaciers which feed the Ganga-Yamuna river system becomes a nuissance with the disposal of urban and industrial wastes effuents along their courses.

To a layman,groundwater seems to be well protected from the human activities and hence seems to be immune to being contaminated, but as such is not the case. Though the quality of groundwater is by and large determined by the hydro-geological history of the region and the mineral constituents of the rock it is found in, it is reported that the quality of the groundwater also tends to be influenced by human activities on the surface (Olaniy et al 1978; Raziuddin, 1986). During the course of replenishment of the depleted reservoir of the groundwater a part of the surface water percolates to the aquifer and thus the contamination of the groundwater may take place. Hence it is explicitly clear that the groundwater ecosystem is also vulnerable to human activities and often prone to get contaminated because there is a slow but steady interaction between the surface and groundwater systems (Attia et al, 1986). The study on groundwater contamination is of much more importance because once the aquifer of the groundwater, somehow, gets contaminated it is almost impossible to purge it and retrieve the purity of the water (Dakshingmurti et al,1973).

It is reported that the contaminant tends to attenuate as it moves through soil and groundwater systems due to physical dilution and dispersion and combination of chemical and biochemical action. The earlier researchers overlooked the importance of such contamination and thought it of no consequences (Timonian, 1935, Walksman 1916). The earlier researchers overlooked the importance of such contaminiation and thought it of no consequence. But it is a fact that the contaminant, whatever the quantity may be, however, manages to percolate to the groundwater and hence this aspect can not be neglected (Dewiest 1986).

It is necessary to predict the movement of contaminants in groundwater with respect to time and space (Ogats & Banks 1961, Shamir& Herlman 1966; Marino;1974)

The outskirts of urban settlements and industrial complexes are often dotted with the municipal landfills and open slurry ponds where municipal wastes and industrial effluents are dumped and waste water spread. During the course of time they decay and degrade primarily due to Physico-chemical and microbial actions and release toxic substances and abnoxious by products which may find their way to aquifers through leachates or in solution with the recharging water (Rao, 1982)

Nitrate (Gerhart 1986), Aldicab pesticide (Dierberg & Given 1986), Human pathogens (Lamka et al, 1980) microbial biomass (Wilson et al 1985), Harvey, 1984, Webster et al. 1985) etc. have been found to percolate and infiltrate to the groundwater from the surface.

But the groundwater contamination may not be wholly attributed to the anthropogenic activities alone. The quality of the groundwater depends on the source characteristics also. The nature and the degree of weathering of the rock where groundwater is contained also plays an important role in determination of the quality of the groundwater (Duke 1980). The rock is the reserve of certain anions and cations and under certain condition it may release them to be present in water in active forms (Page & Binglam, 1973).

Certain rocks like fluorophar, topaz, aptite and phosphorite are rich in fluorine upto 48.67% and in the regions where these rocks are found groundwater is reported to contain high conc of fluoride (Jolley et al.1970; Jha and Jha,1985).

Against the background of the as discussed above importance of groundwater and the chances of its being contaminated the evaluation of the status of groundwater consumption and its potability and aesthetic values becomes important.

A global survey on water quality indicated that each year 500 million people are affected by water-borne a water associated diseases and as many as 10 million-half of them being infants-die (WHO, 1970). 25% of the worlds hospital beds are occupied because of domestic consumption of unwholesome water (WHO, 1976).

The problem of potable water supply is much more acute in the third world where 85% of the rural people and 25% of the urban people have no access to potable water (WHO, 1976).

With the view to emphasise the need of greater attention to the necessity of potable water supply to one and all, International Drinking Water and Sanitation Decade 1980-90 is being currently observed every where.

As early as 1948, the Union Government of India recognised the importance of potable water supply and founded Environmental Health Committee to look into the rural water supply programme.

In the national level survey (1972) it was found that in 34000 villages, water resources were infected with bacterial contaminants and their consumption resulted in chlera. The water of 300 villages were found containing guinea worm (Naru dracuntisis).

In the Fifth Five Year Plan rural water supply was brought under the Minimum Needs Programme during which 10% of rural population or about 64,000 villages were covered with potable water supply.

Out of a total 2921 towns and cities in the country only 1770 (60.6% of total) are given treated water supplies (Pradhan, 1977). Major portion of the semi-urban and sub-urban areas in the country are dependent in the groundwater sources to meet their daily water demands. In Delhi also there is a limited supply of water. Here the total supply is 253 MGD only being 64% of the total demand, whereas the remaining 36% is supplied with groundwater resources (Verma 1979).

The villages receive even less sincere attention in this respect. There, the situation is worse because of improper location & poor maintenance of wells, lack of waste water drainage (Aboo et al 1968), poor construction of well (Piskin, Rauf, 1973), source contamination and treatment deficiencies (Craun and Mc Cabe 1973) and unsanitary methods of drawing water (Kaushik & Prasad, 1964).

The deterioration of chemical quality of water leads to manifestation of diseases like methemoglobinemia and even cardio vascular disorders with blood pressure changes. But the diseases associated with the chemical pollution account only 1% of the total water-borne diseases. The chemical contamination occurs regionwise and location-wise but the biological contaminants seem to be ubiquitous. 99% of the water-borne diseases occur a a result of bacterial and viral contaminations of water (Craum & Mc Cabe 1973) like salmonellosis, Gastrointritis, Diarrhoea, Shigelloris, Amoebiasis, Infections heptitis and their 70% of outbreaks owe to non-municipal water supply (Craun, 1979) It is reported that 1% of human and animal population is carrier of salmonella but 90% of them don't exhibit clinical symptoms (More & Duncan 1976).

Bagchi et al (1962) reported that 80% of the mortality in rural communities is a result of water-borne diseases. Thus it is explicitly clear that drinking water in the major index of health well being of the people. The presence of any of the chemical and or bacterial constituents in excessively higher levels make such waters less potable and unfit for consumption. Keeping in mind the significance of the quality of groundwater and its consumption by an urban village population the present investigation has been undertaken.

1. Assessment of the chemical and biological quality of the groundwater of Aligaon from relected handpumps and dug wells.

2. Comparision of these observations with the standards prescribed by WHO, ICMR and ISI.

3. Observance of the influence on the groundwater quality by the polluted sources of waters in the vicinity of the village-Aligaon.

Aligaon is a typical village situated in the vicinity of the Badarpur Thermal Power Station (NTPC unit). The entire pupulace of the village is dependent on groundwater for their consumption and civic purposes. On the very outskirts of the village a big slurry pond is situated where the effluent from the BTPS is dumped. Besides an ashpond, the partially treated sewage released from the Okhla Sewage Treatment Plant is frequently used for irrigation of the intensive agriculture in the village.

These two sources of polluted water may be somehow enflueneing the groundwater quality.

LITERATURE REVIEW

REVIEW

A. Seasonal variation of Water Quality

In view of the radically different climates round the year, the physico-chemical and bacteriological quality has been believed to be largely influenced by the variation in season. The parameters like Temperature, rainfall, water table etc. have been found to alter the quality of the water. A yearly study carried out on two private home wells one dug and another drilled found in different geological formations in New Jersey indicated that the season of the year is a major factor controlling the number of bacteria (Voelkar et al 1960) High counts were enumerated in warmer months, decreased through fall to a minimum values about January. From a comparison of the air temperature trends with the coliform courts, they suggested a very high order of correlation. They also noticed a distinct relationship between the increased levels of water in the wells following rainfall with the enhanced number of coliform thus demonstrating the influx of surface bacterial contaminants as a result of rainwater percolation.

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A study carried out on the wells in Okhla, Kanjhawala and Najafgarh areas in Delhi showed similar results (Kaushik and Prasad, 1964)

A study on fecal coliforms and fecal streptococci in streams of New Guinea Highlands revealed the same trend. (Feachem, 1974). Taylor et al. (1974) observed a remarkable improvement in the rate of infiltration of surface water to the aquifer with the lapse of time.

A wide range of water borne diseases were studied with reference to their incidence in different months of the year to show a seasonal variation with an increase in percentage of incidence from January to July and decreased in winter months i.e. July to December (Weibel et al 1964).

Olaniya et al (1969) observed high levels of nitrate during rainy seasons, when they studied well water quality in Jaipur City.

Piskin (1973) reported higher level of Nitrate

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in groundwater of Nebraska in winter and lower in late summer.

Ramana Rao et al (1973) encountered significant increase in the ammonia, chlorides and nitrates in one sample of raw water after rainfall. Kaushik et al (1963) have explained the change in terms of seasonal parameters. The findings of Sandhu et al. (1979) serve to illustrate similar variation. They observed that the variables like pH, and temperature of water affect bacterial proliferation and density.

B. Movement of Contaminants

In this section an endeavour has been made to review the literature available on the path ways of contaminants in groundwater. Several researchers have reported that the quality of the groundwater tends to be influenced by the anthropogenic activities and the presence of the sources of pollutants in the vicinity of the region (Raziuddin, 1986). However, not much literature on the actual mechanisms of the movement of contaminants is available and

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this aspect of groundwater contamination is least studied.

The possible ways of the contaminant movement from the surface to the aquifer seem to be through seepage, infiltration, percolation and intrusion etc. A small fraction of the rainwater annually recharges the aquifers (Dakshinmurti, et al, 1973). and thus carrys the pollutants in solution with it. In the case of landfills, slurry ponds and polluted water bodies, the contaminants seep to aquifer through leachates etc. (Olaniya et al, 1976). The rate of percolation is determined by the nature of the rock underlain beneath the surface. The pervious, perforated and unconsolidated rock offer a sieve-like passage to water from the above to the aquifers. Sometimes the hard and consolidated rock also develops fault, fracture and sink holes and then serves as avenues to unimpeded passage of water.

Apart from the vertical movement of water, there is also a horizontal flow of groundwater inside the aquifer like that of a river and

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hence once an aquifer somehow gets contaminated, contaminants move horizontally and pollute other groundwater systems too. In order to check the horizontal spread of contaminants in the groundwater aquifers, underground hydraulic barriers are recommended to be erected (Das and Shrestha, 1986)

The movement of the contaminant from the surface to the aquifers of groundwater is so well established that even the aldicarb, pesticide, which in used in a limited scale in citrus groves in Florida has been found to be present in the groundwater of the region (Dierberg and Given, 1986). Handa (1983) also has found the traces of fertilisers used in the field to be present in the groundwater of shallow aquifers. Gerhart (1986) found nitrate from a manured field in Pennsylvania to percolate in large amounts to the groundwater systems through sink holes in the rock bed beneath the surface. Rao and Rao (1972) have reported groundwater pollution by Industrial waste. In addition to the movement of contaminants from the surface to the aquifer, the soil and rock where the

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groundwater in contained also serves as a source of contaminants to the groundwater system (William et al, 1974).

The concentration of metals in the rocks varies mainly with parent magma and thermodynamic crystallisation process (Duke, 1980). For example, sedimentary rocks contain higher concentration of cadmium than that of igneous rock (Page and Bingham, 1973). Volcanic eruption, natural weathering and erosion of rocks and soil and sometimes the seawater intrusion in the groundwater system also introduce contaminants there.

However, the real problem of the movement of contaminant remains enigmatic to be understood. Some researchers have tried to workout Simulation Models to predict the movement of contaminant from the view point of geo-physics.

In 1930, De Glee in Holland conceived a method to quantity the vertical flow of water through the Leaky bèds. Now-a-days computers are widely employed to understand the problems

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related to the movement of contaminant with respect to three dimensional space like convective - dispersion problem of contaminant in groundwater (Khaleel and Raddel, 1986).

The biological contaminants in the groundwater may be native, introduced during drilling or may be infiltrating there through leachates but in all cases the microbes are found to be capable of survival at a very low concentration of nutrition. (Kuzentsov et al, 1979).

Stetzenbach et al, (1986) in their study on isolation, identification and growth of well water bacteria have found Acinetobactor spp. to dominate (54%) of total number of isolates measured by acridine orange direct count (AODC).

C. Chemical Quality and Incidence of Diseases

Though the diseases associated with chemical contaminants (excluding methemoglobinemia) of groundwater amounts to one percent of the total water-born diseases (Craun and Mac Cabe, 1973), evaluation of various chemical

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constituents in groundwater is of paramount importance. The researches pertaining to chemical contamination are in galore.

During an investigation covering water quality of 50 dug wells in Bhopal City Aboo et al.(1968) found 24 percent of the wells under observation to have chemical concentration in higher levels than the permissible ones. Pande et al. (1979) reported that 73% of the wells studied in Nagpur had nitrates above the maximum permissible level of 50 ppm stipulated by ICMR.

Studies on nitrate and nitrite content in groundwater assume greater significance because they are reported to cause methemoglobinemia in human body (Meletechie and Robertson, 1949, Walton, 1951).

Recent literatures are replete with examples to illustrate the role of nitrate and nitrite in drinking waters when present in concentration higher than that of prescribed limit. The significance of nitrate as a pollutant was recognised as early as 1949 by

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Robertson and Riddle. During their study on 2000 wells in Canada, their survey revealed that 18.8% wells contained nitrate in 50 ppm concentration and 5.3% wells were found to have concentration above 300 ppm, wherein the Public Health Service Standards recommended 45 ppm as the permissible limit.

The health hazard associated with the abnormal concentration of nitrate on human population is extensively studied and well documented. Experiment performed regarding the nitrate toxicity in dairy heifers to study the effect of nitrate/nitrite on reproduction, growth, lactation and vitamin A nutrition showed an inhibition of growth and a significant reduction in Vitamin A level (Davison et al, 1964). They further reported that the enhanced level of nitrate had a direct relationship with abortion rate and reproductive difficulties and also an indirect relationship with the milk yield and utilisation of vitamin A by the body.

Mathemoglobinemia in reported to be a potential cause of impairment of proper supply

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of oxygen to the tissues. Though the exact molecular mechanism of formation of mathemoglobin in body is still to be fully understood, the conversion of hemoglobin to mathemoglobin has been explained to occur as follows: Nitrates do not directly convert to nitrites by gastrointestinal microflora (Ridder and Ochme, 1974). Haemoglobin (Hb), the oxygen carrier of erythrocytes of blood, consists of four identical subunits, each containing a polypetide chain (globin) with a heme group. Every one of the hemegroups contains an atom of iron which in oxygenated-called oxyhemoglobin (HbO_2) containing ferrous in bivalent (Fe++) form. Methemoglobin is the oxidised product of Hb. in which the iron is in trivalent (Fe+++) form. On transition from ferrous to ferric state, haemoglobin loses its ability to combine with oxygen and thus hampers the supply of oxygen to tissues. Infants and young babies are particularly susceptible to nitrate toxicity because of its more ready conversion to nitrite and thus reaction with Hb by the intestinal bacteria in the chlorophydric stomach of infants. (Pande et al, 1979).

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Methemoglobinemia was correlated to high nitrate content for the first time in 1945 (Davison et al, 1964).

The results obtained by Waltom (1951) demonstrated increased susceptibility of young babies of 2-3 months to this disease. The findings of Schmidt and Knotck (1970) appear to be supporting the same hypothesis. They reported that the mean nitrate content of water used for baby food formulation for the consumption by children of Czechoslovakia ranged between 18 to 257 ppm and 75% of the infected babies had been consuming the water containing more than 100 ppm of nitrate.

A case of methemoglobinemia was reported in one month old baby in Texas, wherein the concentration of nitrate in well water sample was found to be 77 ppm. (Miiler, 1977). Pathological examination of the blood sample of the victim showed 50% level of methemoglobin in blood. The nitrate ingestion of more than 5 mg in 24 hours produced the disease in young babies (Shearer et al, 1972). The toxicity of nitrate

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(resulting in methemologlobinemia) has been reported to be enhanced in the case of babies suffering from other illness especially from the gastro-intestinal disturbances (Comly, 1945, Shearer et al, 1972)

The presence of bacteria along with a high nitrate content was found to be necessary for producing methemoglobinemia (Shearer et al, 1972).

In a study conducted to assess the nitrate content in drinking water, Parson (1977) claimed that in every well documented case involving methemoglobinemia, by high bacterial content. Highlighting the possibility of controlling the bacterial population in water effectively, the author suggested that the nitrate concentration as a standard should be raised to at least 100 ppm.

Besides methemoglobinemia, presence of nitrites and nitrates in drinking water may lead to the development of organic pollution. Various investigations have been undertaken to explore such possibility (Pande et al, 1978).

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The paper suggests that the wells having nitrite above 0.1 ppm indicate the existence of organic pollution.

In an attempt to investigate the possibility of formation of dimethyl nitrosoamine, a potent carcinogen, mutagen and tetragen, Ayanaba and Alexander (1974) observed an increase in nitrosoamine level with the increase of acidity, increasing dimethylamine and nitrite concentration. They further reported, a pesticide, Thiram, as a source of dimethylamine convertible to dimethyl nitrosoamine.

The formation of nitrosoamin in soil leads to the ready leaching of these into groundwater. The problems posed by the formation of these toxicants and their entry to groundwater supply were found to be more acute because of their resistance to biodegradation (Tate and Alexander, 1975). Nitrosoamine may arise, in vivo, as the end product of ingested nitrites, some of which may also be formed by the action of gut bacteria on ingested nitrates from water and on secondary

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or tertiary amines present in food (WHO, 1971). Invitro formation of nitrosomines in samples of water and sewage have also been illustrated by Naikado et al, (1977).

Like nitrate and nitrites, the effect of other chemical constituents are equally significant and their toxicity may directly result in serious disorders in human system or may indirectly influence the spread of specific diseases. For instance, hardness, alkalinity, chloride and fluoride have been studied in a number of water samples and their toxicity in human and animal populations is ascertained.

A survey on chemical quality of well waters in parts of Ujjain district in connection to the prevalence of Guinea worm (Naru dracuntiasis) showed that the presence of high alkalinity, high chloride, high calcium and magnesium carbonate are favourable to the growth of cyclops that in causative of the disease (Kapoor, 1973).

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Well waters from eight village groups of Ajmer was analysed for their content of fluoride, chloride and total dissolved solid (Bhargava et al 1978). An interrelationship was shown between total alkalinity/total hardness (TA/TH) ratio and fluoride. Results showed that dental fluorosis increased with residual concentration of bicarbonates, indicating a synergistic influence of residual bicarbonate with fluoride. Therefore, the incidence of mottled teeth was found to be more prevalent in the villages where TA/TH ratio was more than unity.

However, hardness of water has been found to have some positive effects to the health. Hardness has got an indirect relation to the mitigation of cardiovascular diseases. Population in hard water areas were found to have a lower mortality due to prevalence of cardiovascular diseases than that in soft water areas(Morris et al, 1961)

Crawford and Crawford (1967) during their operational studies on cardiac lesions found more ischaemic myocardial diseases in men from

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soft water areas suggesting an increased susceptibility of myocardium in the area with soft water. A negative co-relation of anecephalus and spinabifidia was found with total hardness calcium content, Na-content and pH in a study carried out on the local water supply (Fedrick, 1970).

Chloride

The chlorine and chlorinated compounds are widely used as disinfectant, herbicides, pesticides and fungicides etc. and thus they are found everywhere in the environment including the groundwater. DDT is reported to be found in the adipose tissues of whale, a native of the Arctic sea. Even at the permissible level of 250 ppm, chloride is dangerous to the ecosystems in many ways because of formation of free residual chlorine (Klein, 1962). Recent findings pertaining to the detrimental effects of chlorine toxicity to the ecological balance (Brungs, 1973; Hall et al, 1981) and the carcinogexicity of chlorine byproducts have attracted attention of the environmentalists (National Academy of

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Science, 1978). In the presence of bromine the chlorine is reported to form ClO_2 by oxidation (Wengert, 1968) and which in turn is toxic to biota. According to Wilde _et_ _al_ (1983), chlorine dioxide is much more toxic to fishes than total residual chlorine having the same concentration. When chlorine is present in water, rapid hydrolysis and substitution reaction take place there and hypobromide is reported to be formed (Carpenter and Macalady, 1976). Some researchers have experimentally proved that a direct relationship exists between chlorine toxicity and temperature. As the temperature goes up the toxicity of chlorine also increases. (Dickson et al, 1977). Workers like Brungs (1973; Bass and Health (1977) have concluded that free chlorine is more toxic than that of compound chlorine.

Chlorine is found to form HOCl in aqueous media and this reaction is reported to be accelerated at pH 7 and more (Mc Kabe, 1960). Chlorine has also got the property to be accumulated in tissues (Warfe _et_ _al_ 1981). In the presence of ammonical nitrogen, chlorine

Contd.......

is said to form chloromine which in turn has got pathological effects on aquatic systems (Mc Kabe _et_ _al_ 1960). At the higher level of chlorine, BOD has been observed to be considerably decreased owing to the death of microbes (Surag, 1968). Surag found the reduction of BOD upto 2mg/l for the absorption of lmg/l chlorine for 5 days incubation. It has been ascertained that due to chlorine, cadmium toxicity decreases because of the fact that Cd is more toxic than $CdCl_2$ (Babich.1982).

Fluoride

Chronic fluorine toxicity is one of the few problems of environmental pollution which has baffled the mankind because of lack of knowledge with regards to its effective treatment and cure. Being the most electronegative element, it is violently reactive (Waldbolt, 1978). Extensive damage to both domestic livestock and crops has been reported due to fluoride pollution (WHO, 1970).

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The chronic fluoride intoxication during the enamel development of infants leads to an endemic hypohasis known as mottled enamel (Jolly et al 1970).

It is demonstrated that for 10-20 cm long rainbow trout, 480 hour LC is 2.7 - 4.7 ppm fluoride (Neuhold and Singler, 1960). The hardness due to Calcium/and or Magnesium can mitigate the fluoride intoxication even though the fluoride conc. is quite high (Neuhold and Singler, 1960; Herbert and Shurken, 1964).

With the fluoride uptake, its conc. in the body goes on increasing with the time, whatever may be the conc. of fluoride at the time of its consumption (Wright, 1977).

It is found to be readily accumulated in oeseous tissues and uptake is directly correlated with aquatic fluoride level and with exposure span of tume (Hemens & Warwich, 1971; Hemens _et_ _al_, 1975).

High level of fluoride in the body inhibits the enzyme action. In the aquatic system,

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fluoride can cause changes in mucosa of gill epithelia and hypertrophy of the ultimo branchial gland in rainbow trout (Neuhold and Singler, 1960).

With the low level, the sublethal activity is marked by stunted growth, low reproductive potential and other detrimental effects to juveniles (Pankhurrt et al, 1980). Fresh water animals are more sensitive to the fluoride contamination and its toxicity is quite pronounced on them (Angellovic et al, 1961; Neuhold and Singler, 1960; Wright, 1977). At 55 F temperature the lethal conc. to 50% of the fish found to be 2.5 ppm and 6 ppm fluoride. (Angelovic et al, 1961). Generally 1 mg of fluoride is retained in the body with the 4.3 mg dietary intake of it and more or less 50-60% of fluoride is discharged out of body through urine and 6% comes out with stool (Spencer et al, 1981).

Sulphate

Sulphate pollution in aquatic system is generally attributed to the formation of iron

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sulfide, decomposition of organic matter and solution gypsum and aldhydrite present in the rock or sediment (Long & Saleem, 1974). But this proposition has been rejected by Craig and Anderson (1979). According to their study, it has been ascertained that sulphate contamination in aquatic system is more from artificial sources rather than leachates from the geological materials.

It is quite evident from a lot of studies that high concentration of sulphate creates a lot of problems starting from eutrophication to corrosion because of formation of sulphuric acid. Sulphate has been found to catalyze the oxidation of organic matters which depletes oxygen content in aquatic system and their reduction gives rise to abnoxious compounds and foul odour (Zaiss and Wasser, 1978). Algae are reported to accumulate sulphate in their tissues and thence their productivity is said to enhance. According to Heimur (1981) in physiologically active cultures, sulphate uptake increases dramatically if it is present in the medium.

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Phosphate

Phosphate, one of the most essential ingredient of aquatic life, causes much more damage to the ecosystem when it is available in high conc. in aquatic environment creating the problem of eutrophication in the water bodies. Phosphate is reported to come to the aquatic system through the process of rock weathering (Livingstone, 1963). Spring bloom and denitrification processes add the phosphate to the aquatic ecosystems in many ways due to the nutrient cycling and life cycle of aquatic lives (Odum, 1971).

The domestic sewage and urban waste water are reported to be appreciably rich in phosphate because of detergent components present there. The non-point application of phosphate fertilisers to the agro-system further exacerbates the problem of phosphorus pollution because a part of which comes to the aquatic system through runoff and causes vegetative bloom or green cancer which ultimately chokes up the water body.

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D. Heavy metals and Trace-elements and their Health Hazards

The heavy metals are probably the most harmful and insidious pollutants because of their non-biodegradable nature as well as their capacity of bio-accumulation in the tissue systems. They are potent to cause adverse effect by impairing the metabolic function of the body at a certain level of exposure and absorption.

Zamansky (1974) has classified heavy metals as those metals whose atomic number exceeds 23. Formerly heavy metals were defined on the basis of specific gravity and all the elements whose specific gravity is more than five were considerd to be heavy metals. The wide differences in the physico-chemical features and toxicological actions of these heavy metals demand a better classification. Many of these elements are essential ingradients of the chemical constituents of the cells and are required to be present in protoplasm in trace amounts. But at high cencentrations most of the heavy metals become toxic in action (Luckey et al.,

Contd.......

1975) Wood (1974, 1975) with the view point of environmental pollution has classified the heavy metals in three groups :

(i) Non-critical elements

(ii) Very toxic and relatively accessible.

(iii) Toxic but very insoluble or rare.

The heavy metals, which are of prime concern to environmentalists and physicians, like mercury, lead, cadmium, copper are grouped in the second category.

Zinc, Copper and nickel are reported to have important role in biological system of the body. Copper and Zinc play very significant role in metallo-protein synthesis and critical metabolic mechanism.

The toxic action of the metal is mainly due to the ionic form of metal present in water (Luoma 1983, Sundo & Guillard 1976). The sediment of the aquatic system is reported to

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serve as a sink of heavy metals (Mathis and Comings, 1973). The animal species dependent on the ditritus because of their higher ability to chelate metals (Gesy et al., 1983) contain higher levels of heavy metals in their tissues (Fostner and Whitman 1983). However, the amount of intake of heavy metals in the body depends upon the parameters like pH, temperature, hardness, turbidity etc. (Azeez and Banerjee 1982) . A number of studies have been done on the toxicity of heavy metals in phytoplankton (Harris et al., 1970, Karup Nielson 1971, Spencev 1980, Azeez et al., 1984).

The toxicity of some heavy metals are discussed below in detail because of their paramount importance in relation to human beings and their presence in groundwaters as well.

COPPER

It is an essential element which takes part in metabolism and other physiological activities (W.H.O. Technical Report Series 1973) and is

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usually considered to be non-toxic for human beings at levels generally encountered in potable water.

Copper is the prosthetic group in hemocyanin, the respiratory pigment in invertebrates like Mollusks; laccase and ascorbate oxidases of Electron Transport System (E.T.S.); tyrosinases and dopamine - B - hydroxylase (Zuberblihler, 1976). Copper is also reported to be micro-nutrients for phytoplanktons (Kallguist and Meadows 1978, Erickson et al., 1970).

At higher levels of consumption of copper, it exhibits toxicological symptoms. At the level of 8 ppm., copper has been found to reduce biomass production by 50 % in S. platensis within 160 hours of exposure (Azeez & Banerjee 1984).

The greatest danger of toxicity arises when children consume acidic beverages kept in copper casks or utensils (Food and Drug Administration) were adversely affected by the

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estimated average intakes of copper (Scheinberg and Sternleib, 1965).

CADMIUM

It is reported to be one of the most toxic metal to man and animal (Friberg et al., 1974). It is also reported to cause itai itai disease (Shimizu, 1972). Cadmium is retained / accumulated mainly in hepatic and renal tissues, thus causing pathological changes of the hepatocytes of the liver as well as glomeruli of kidney (Itokawa et al., 1974, Colucci et al., 1975).

The occupational hazard associated with chronic cadmium exposure leads to lung diseases and renal failure. The lung disorders are primarily suggestive of pulmonary emphysema. The most common abnormality from chronic cadmium exposure involves renal toxicity characterised by proteinures.

Other disturbances of renal tubular function include glycosuria, aminoacid ureas, decrease

Contd.......

in urine concentrating ability and abnormality in renal processing of uric acids, calcium and phosphorus (Drinking Water and Health Vol. 3, 1980).

IRON

Iron is an essential element in haemoglobin and also plays an important role in human nutrition. Hence it is required to be present in body in trace amount. But it becomes highly toxic when administered in high quantity. Adults are generally well protected from oral over dose but children are vulnerable to iron toxicity due to excessive ingestion of iron supplements in baby foods that have been commercially prepared for infants (Fairbank et al., 1971).

MANGANESE

Kawamura et al., (1941) reported an epidemic of manganese intoxication in Japan resulting from the consumption of contaminated well waters. They have reported neurological symptoms and death of two patients whose

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tissues were found to contain high level of manganese.

A survey on Unnao district in U.P. by Indian Toxicological Research Centre found the levels of manganese in well water to be 3-20 times the permissible limit. The consumers were reported to have developed neurological syndrome resembling that of manganese encelopathy (Anon. 1971).

LEAD

Lead is a toxic metal and it is found to accumulate in the bodies of man and animal. Synden et al. (1971) have described the effects of lead as those of poison on human beings.

The study conducted by Drasch (1982) on prehistorical modern human bone has revealed a close relationship between life standard and lead level in the bone. Lead is also found to retard the development of brain of children if present in excessive level in the body.

Contd.......

Lead has been demonstrated to be extremely deleterious as it is related to haem biosynthesis (Chisholm, 1971). Goyer and Rhyne (1973) have reported that elevated level of lead in blood disrupts the blood enzyme delta - amino leveulinic acid dehydratase (ALAD) activity in human body and can inhibit the haemoglobin formation.

ZINC

The role of Zinc in the biological system is better documented than many other heavy/trace metals. Its deficiency leads to a wide array of deficiency diseases (Chesters 1978) Zinc is found to be less toxic when taken orally (Evans, 1976), otherwise it is highly toxic. High mortality in fish has been reported due to Zinc intoxication which causes internal hypoxia (Skidmore 1970, Llyod, 1960).

NICKEL

The role of nickel as an essential element to plant and animal life is quite less explored. But it is reported to be essential to chemo-

Contd.......

lithographic micro-organisms, some strains of Oscillatoria and other plants (Kaltwasser and Frings, 1980, Bertrand and Dewolf 1967). Dixon et al., (1975), Polacco (1976) have also confirmed the plant urease to be a nickel containing enzyme.

Nickel has been shown to be toxic by several workers (Berg & Burbank, 1972), Sunderman, 1977). Nickel salts exert their action mainly by ´gastrointestinal irritation´ rather than by inherent toxicity (Scroeder et al., 1961).

SOURCES OF HEAVY METALS

The main sources of heavy metals to the aquatic systems are (i) rock and soil (ii) atmospheric fall out (iii) direct discharge of metals from human establishment to the aquatic system (Welliam et al., 1974). The first source is basically natural one and last one is anthropogenic. The concentration of metals in the rocks varies mainly with parent magma and thermodynamic Crystallisation process (Duke 1980). Besides, the release of heavy metals from the rock reserve to the water in

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active forms depends upon the degree of weathering and erosion of the rock as well as the parameters of the water itself.

Some anthropogenic sources of heavy metals to the aquatic environment are discussed below in detail.

AGRICULTURE AS A SOURCE OF HEAVY METALS.

Addition of metals knowingly or unknowingly is the main way how agricultural practices become a source of a heavy metals (Fostner 1980, Kaiser and Tulg 1980).

The use of metal compounds like agrosan and ceresan, zineb or mercurial compounds for seed treatment/dressing, foliage sprays of micronutrients like zinc sulphate (Gold Water 1971, D´Itri and D´ Itri 1973, Page and Bingham 1973), application of fertilizers which contain metals as impurities. (Schroeder and Balessa, 1963, Nordgerg, 1974) irrigation water, (William et al., 1974) wide use of organometallic pesticides, herbicides- and insecticides are some of the methods of

Contd.......

direct addition of metals to the agro-system by human beings which ultimately find their way to aquifers, albeit in small quantities.

FOSSIL FUEL CONSUMPTION

The concentration of metals in the fossil fuels like coal and oil varies with sources and process of their formation (Swaine 1980) but they are found to be there. Nickel concentration ranges betweenm 10 to 10,000 ng/g in ash and 0.2 to 3 ppm in coal and 0.01 to 16 ppm in oil (Foster 1980). Copper has been reported to be present as 400 ppm in coal ash and 19 ppm in oil. Kruegraf (1972) has found zinc to be present in the level of 0.6 ppm in oil and 1000 ppm in coal ash. Likewise the oil contains significant amount of lead and that is found to be present in automobile exhaust also in an appreciable amount.

The exponential growth of fossil fuel consumption has lead to the addition and accretion of thousands of tons of toxic metals to the environment.

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U.S. EPA has determined that from the 3300 x 10^9 Kgs. of coal consumed during 1975, 0.66 x 10^6 tons of nickel was sent to the enviornment as aerosol, 75 % being removed in ash produced during the process (Schmidt and Andrey 1980). This ash is usually dumped in the landfills and hence the metal may finally percolate to the aquifers through leachates.

INDUSTRIES:

Industries whicn contribute heavy metals / trace elements significantly to the environment can be listed as below :

(1) Electroplating industries.
(2) Pharmaceutical industries.
(3) Paint industries.
(4) Iron & Steel industries.
(5) Textile industries.
(6) Cement industries.
(7) Tannery processing industries.

Page & Bingham, 1973 Robinson et al., 1975, Yost 1979, Duke 1980, Fostrer 1980, Kaiser and Tolg, 1980).

Contd.......

Of these electroplating and electrolysis industries are the most important consumers of total metal produced in the world as well as they discharge the highest amount of metals to the environment through their effluents. For example, of the total consumption of mercury in 1975 in USA i.e. 1770 tons, about 30 % was consumed by electrolysis industries (Kaiser and Tolg, 1980). About 5 x 10^5 kg of copper has been estimated to have escaped from the electroplating industries in USA out of total consumption of 5.3 x 10^6 kg of copper during 1973 (Robinson et al. 1975).

This industry is also the main consumer of cadmium (Fost 1979). One important use of cadmium and nickel in electrical industries was the production of Ni-Cd batteries. The PVC production is another important source of Cadmium pollution. Likewise tannery processing plant has been found to be a source of Cr pollution and paint industry has been alleged to be a source of lead pollution. The metal contaminants are found to be mobile in the environment and hence may contaminate the ground water as well.

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DOMESTIC SEWAGE

Though the concentration of heavy metals/ Trace elements are much less in domestic sewage in comparison to the industrial effluents, the vast quantum of sewage generated from the big cities poses a serious threat to the aquatic eco-system. Robinson et al., (1975) have estimated that about 5×10^5 kg of copper is discharged out in the form of domestic sewage on world scale. The metal in the sewage get concentrated in the sludge and portends dangers where this sludge is applied.

MINING AND ORE PROCESSING

Mining and ore processing is another source of heavy metal pollution to the aquatic system (Brown, 1977). The acidic nature of the mine and ore drainage mobilises the heavy metals in the aquatic eco-system. Deep coal mining is found to directly contaminate the ground water.

Zinc mining amd ore processing is one of the

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main Cadmium source to the environment (Jennet et al., 1979, Yost 1979).

Smelting process of sulphide ores of Cu. Pb. and Zn is reported to contribute 15,000 to 30,000 tons / year mercury to the environment (Fostner 1980).

RUN-OFF FROM THE STREETS & HIGHWAYS

The automobile exhaust, SPM fall out, residues of coal tars etc. contribute high concentration of Cr, pH, Cd, Ni, Cu, Zn, etc. on the roadside dust, their run-offs contribute a significant amount of heavy metals to the aquatic eco-system.

LAND CLEARING

Erosion is the main contributor to the mobilisation of metals. During land clearing, the metals concentrated in the highly humic soil is getting transported to the water bodies and thus it is a secondary source of heavy metals in the aquatic system (William et al., 1974).

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Many workers have studied the quality of drinking water in relation to heavy metals/ trace elements (Craun and Mac Cabe, 1975, Neri et al., 1975, Olwin 1977, Schroeder and Kraemer, 1974).

These studies have indicated an association between the water quality and the mortality from cardiovascular and other chronic diseases. A significant positive correlation between the mortality from various types of cancer and the conc. of trace elements in water supplies has also been reported. (Berg and Burbank, 1972, Sunderman 1977). The metallic pipe network laid down for water supply has been found to be a major source of metals in drinking water (Craun and Mac Cabe, 1975). Corrosion and Corraison of household plumbling also have found to contribute heavy metals in water (Drinking Water and Health Part I, 1977). However, the consumption of heavy metals along with drinking water is found to be retained/accumulated in kidney, liver, spleen and muscle and reported to disrupt the metabolic processes. The breaking down of metallothionein like proteins and

Contd.......

other carrier molecules play an important role in the process (Azeez et al., 1984).

3. BACTERIAL POLLUTION AND WATER-BORNE DISEASES

The growth of microbial population overloading the water supply systems frequently results in diseases such as cholera. The first record of the spread of cholera is from India in 1817 and since then such epidemics have continued erupting in many parts of the world (Liptak, 1974). The microbial diseases account to 99% of the total water-borne diseases (Craun and Mac Cabe, 1973) and thus it is of serious concern in determining the degree of potability of drinking waters.

The other significant water-borne diseases are Gastroentritis, Typhoid, Infectious hepatitis, Diarrhoea, Shigellosis, Salmonellasis, Amoebiasis etc. (Wiebel et al., 1964).

Bagchi et al. (1962) in a study of 170 wells in Lucknow district of U.P. have estimated that mortality in rural community due to water-borne diseases rates to 80 %.

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Untreated groundwater has been found to be source of potable water wherein maximum number of water-borne diseases outbreaks have been observed (Wiebel et al, 1964). Similar results were obtained in a study by Craun (1979) wherein maximum number of the epidemeological outbreaks (63%) occured in communities served with untreated groundwater.

Most probable number (MPN) and specific plate count (SPC) have been recommended as valuable indices for estimating the potability of water.

A survey on New Guinea village water supplies was carried out to compare the level of faecal pollution in tradition water with that in wells. 51.5 percent of tests showed E.Coli. counts of 10/100 ml while in 6 percent, the levels were greater than 100/100 ml. (Lane, 1967).

Coliform level was found to be more than 1000/100 ml in 50 percent of the 50 wells analysed in Bhopal city whereas only 4 percent sample showed MPN less than 20/100 ml. (Aboo

Contd.......

et al, 1968). Improper location, poor maintenance and lack of waste water drains were suggested to be primary causes of water quality deterioration. In one of the studies done on wells provided with handpumps, it was found that the chemical quality was within the permissible limits but 20 percent of wells indicated heavy bacterial pollution with coliform index exceeding 1100/100 ml. The reason putforth for the poor bacterial quality was the monsoon season during which sampling was done (Pathak, 1969).

In one examination of various water sources in Tarai region, it was found that in all the samples Coliform count exceeds the permissible limit (Thapliyal et al 1972).

Enterococci was shown to bear significance over the total Coliform count in an experiment by Mathur and Ramanathan (1966) as the former did not show multiplication outside the human body.

Besides the enterococci involved in early isolation procedure, their presence confirm

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recent pollution in the water sources. However, the above advantages with regards to Coliform enterococci were contradicted by Geldreich (1969). It was stated by him that Faecal coliforms were the most suitable indicators of a low-level faecal contamination in groundwater by the fact that faecal streptococci densities below 100 organisms per 100 ml have the variety liquifecans, which is eubiquitous in the environment, therefore, carries little sanitary significance when present in ground water.

Pseudomonas aeriginose which is responsible for persistent ear and urinary infections was proposed to be an important index in assessing bacterial quality of water (Nemedi and Lanyi, 1971). 21 samples that had no Coliform indicating the necessity along P.aeriginosa.

21 out of 35 groundwater samples contained P.aeriginosa and had no demonstrable Coliforms, thus indicating the isolation of P.aeriginosa to be necessary along with Coliform estimation.

Contd.......

Faecal coliform together with faecal streptococci was found to yield an important index which when compared with the standard, revealed the origin of pollutants i.e. man or pig, the ratio for which being a constant (Feachem, 1974).

The qualitative and quantitative determination of phytoplankton and zooplankton have received attention in terms of their signifinace in the drinking water supplies. Some reports on the potability of water have shown the inclusion of biological characteristics as a part of the studies. However, one such study was undertaken on waters from different wells in Northern India (Gulati and Sarkar, 1961), which showed the presence of Copepods, Crustaceans and Chironomid larvea. Cyclopes were obtained from a few of the wells.

Aboo et al (1968) observed a wide variety of phytoplankton and zooplankton in 72 percent of the 50 covered and uncovered dug wells in Bhopal. Bacilarivphyceal among phytoplanktons and crustaceans among zooplanktons were found to be most predominant. Mosquito larvae were

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also obtained from 20 percent of the wells and in 4 of the wells adult cyclops were recorded.

Naru dracuntiasis, the guinea worm disease, was found to be prevalent in some parts of Ujjain in M.P. Cyclops that are responsible for the diseases were reported to have an access to human beings through the drinking well waters (Kapoor, 1973).

E. **Miscellaneous**

Depth of the well has been found to have a profound effect on the pollution load of the water. Such a correlation was obtained by Olaniya et al (1978) in the pollution studies of well waters in sewage farms at Jaipur. Nitrate concentrations were observed to be inversely related to the depth of the well (Brooks and Ceck, 1979). The ratio of total Coliform to faecal Coliform was used for regression against the well depth resulting in the observation that E.Coli decreases with an increase in well depth as compared to the total Coliform (Sandhu et al, 1979).

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Surveying the rural water supply, Subrahmanyan and Bhaskaran (1948) came out withl a recommendation of 50 feet as the optimal depth of the well from the view point of safety of water and yield, sufficient for domestic use. Lately, Henderson and Sellers (1978) have given a mathematical model to predict water quality at different depths of a reservoir.

Age of the wells might be a factor in determination of the quality of water. The level of hardness and chloride were observed to be high for older wells (Olaniya _et_ _al_, 1969). The reason for the deterioration of ground water quality with time in a well was given as the continuous withdrawal of water (Bhargava _et_ _al_, 1978). Therefore to maintain the water quality a proper balance between withdrawal and recharge has been recommended.

Overflow of sewage, seepage from the landfills, canals and contaminated flood waters were some of the reasons proposed for the increase of outbreaks of diseases due to various contaminants in groundwater (Wiebel et al, 1964).

Contd.......

A direct relationship between chemical and bacteriological quality of water has been established by Olaniya *et al*, (1978). During the evaluation of nitrate content in well waters, seepage from the rivers in which effluents from several sewage disposal plants were discharged, septic tank effluents landfills leachlates and fertilisers run offs were found to be responsible of elevated concentration of nitrates in well waters (Piskin, 1973).

A variation in septic tank distance from well had a pronounced effect on the filteration capacity of the soil adsorption system. The distance enhances pollutant removal by the soil from the septic tank waste water seepage. (Sanoky *et al*, 1979).

However, tube wells and driven wells were found to provide economic methods of supplying water of good hygienic and potable quality than that of open dug wells.

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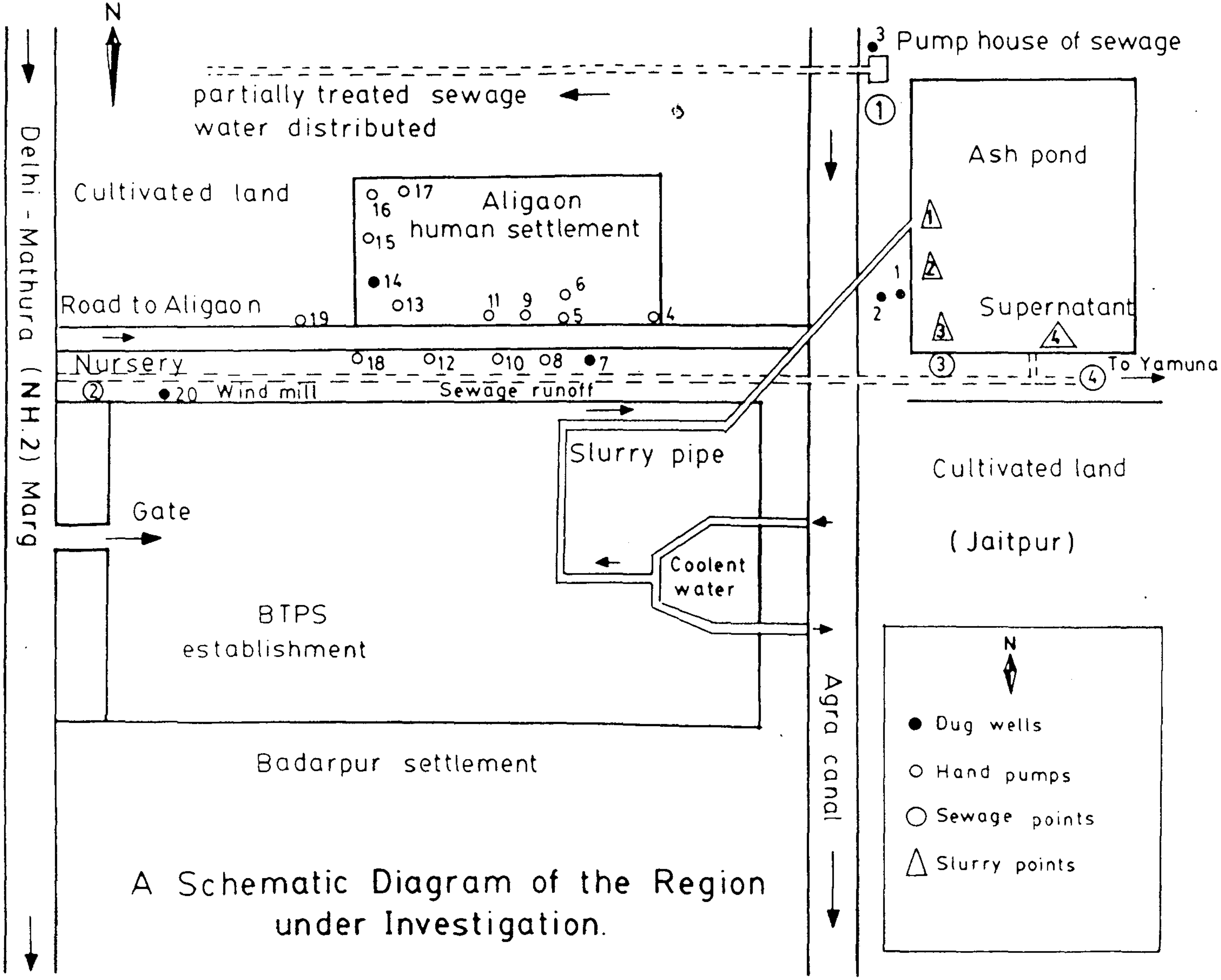
MATERIALS AND METHODS



A Schematic Diagram of the Region under Investigation.

MATERIAL AND METHODS

Description of the village:

The village Ali is situated at the southern most fringe of the Union Territory of Delhi on the Delhi-Mathura Road (NH-2). It is in the vicinity of the Badarpur Thermal Power Station (NTPC Unit) which dominates the landscape of the region.

The village populace, more than 3000, entirely depends on the groundwater resources to meet the needs of water for consumption as well as civic purposes.

The rationale behind the selection of Aligaon for the investigation on the status of ground water of the village emanates from the fact that the possible sources of contamination exist there. On the very eastern outskirts of the village an ash pond is situated which is more than 4 square km in area and where large amount of slurry from the BTPS is dumped. This slurry is reported to be heavily polluted in terms of heavy metals, organic matters

Contd.......

and anionic contaminants. These contaminants are suspected to be percolating to the aquifers and thus degrading the quality of the ground water. Further more, the village is dangerously juxtaposed to the BTPS and intercepts the appreciable amount of fall outs of SPM. These fallouts contain heavy metals and may get mobile under certain condition in the soil to leach out to the aquifer only to contaminate the ground water.

The quality of the ground water is again feared of being influenced by the perennial flow of partially treated sewage water in the region. The secondary treated sewage water from the Okhla Sewage Treatment Plant (situated nearby) is mixed with the raw sewage (as the capacity of the plant for treatment is limited to 100 MGD while the influx of raw sewage here is 180 MGD) and this admixture is released for the purpose of irrigation. A part of this partially treated sewage water is collected in Aligaon and later on pumped out to feed the small channels and distributary networks to irrigate the intensive agriculture practised here . The perennial inundation of the fields with this water may lead to the degradation of the ground water. This

Contd.......

partially treated sewage water is polluted not only in terms of chemical but also in terms of biological parameters and may be suspected of recharging the shallow aquifers and thus contaminating the ground water.

Against the background of the above discussed sources of pollution, it was planned to investigate the ground water contamination. For the sake of this purpose, 18 Handpumps and 2 Open dug wells (there are only two dug wells in the village) whose depth varies from 30 to 100 feet were chosen for the collection of ground water and their examination.

For the assessment of the influence on the ground water from the above discussed sources of pollution, a thorough examination of slurry water and partially treated sewage water was also done.

In order to get a preliminary idea of the chemical nature of the slurry and SPM, the following data pertaining to the quality of the coal and ash of BTPS were collected.

Contd.......

For the generation of 720 MW of electricity, 7500 tons Bituminous coal a day is consumed which is transported here from Dhanbad, Bihar mines.

The coal analysis report is as such:

Total moisture : 6.74%
Ash : 34.27%
Volatile matter : 17.49%
Fixed carbon : 41.54%
Usable heat value is 4609 K cal/ton.

After the ignition of the coal at 1250 C, volatile matter escapes to the environment leaving about 2500 tons coal ash/day in which flyash is 80% and bottom ash 20%. Better part of fly ash is collected by electro-static - precipitator (ESP) and then it is piped out to the slurry pond in suspension with water.

The flyash and SPM fallout are the major sources of contaminants in the region and hence it is necessary to know their physical and chemical composition.

The composition of fly ash is

Contd.......

(1)	Silica as SiO_2	56.02%
	Alumina as Al_2O_3	25.84%
	Iron Oxide as Fe_2O_3	5.20%
	Magnesis as MgO	0.20%
	Lime as CaO	0.50%
	Alkalies as Na_2O	0.2%
	Sulphuric anhydrates	- traces
(2)	Roundness	2 mm
(3)	Fineness	1800 cm^2/gm

Apart from the fly ash of ash pond and SPM fall out, another major source of pollutants in the region is the partially treated sewage water which is there used for intensive agriculture. The chemical and biological analysis of that water was done and is presented in the result section of the dissertation.

As is it an accomplished fact that the quality of the ground water is also determined by the hydro-geological formation of the region and the mineral constituents of the rock and soil where it is found in, it is relevent to present the geological history of the region where Aligaon is situated in.

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Geological History:-

Aligaon, situated at 100 m above msl lies approximately at 29.15 N latitude and 77.05 E longitude and on the western part of the catchment area of the Yamuna which flows nearby. The soil is of recent formation (pleistocene period) and it is alluvium brought by the floods of the Yamuna. The ground water yield is moderate (50 - 150 cubic meter/hour) and nature of the ground water is slightly saline. (Reports of Central Board for the Prevention and Control of Water Pollution 1980-81). Under the thick alluvium, Delhi quartzite is interspersed.

The scheme of selection of sample sites :-

The sites of stations of sample collections can be classified in three categories whose detailed descriptions are presented below:-

I. Partially Treated Sewage Water.

II. Slurry Water of the ash pond.

Contd.......

III. Ground Waters.

I. Partially Treated Sewage Water.

In order to assess the load of pollutants in the partially treated sewage water, the samples were taken from the four stations mentioned below:-

1. The pump house, where there is a well and in which the partially treated sewage water from the Okhla Sewage Treatment Plant is received and later on pumped out for irrigation.

2. The nursery point, where the excess sewage water after irrigation enters the drain channel on the way to the Yamuna.

3. The point of sewage drain, just before mixing with the supernatant of the ash pond.

4. The point of sewage drain, just after

Contd.......

the homogeneous mixture with the supernatant.

II. **Slurry water of the ash pond**

1. A point at the mouth of the pipe no. 1 before falling of the slurry to the ash pond.

2. A point, 40 meter off the entry of the slurry, where the suspended matters partially settle down.

3. A point, 100 metre off the entry where the suspended matters almost settle down.

4. A point, 1 KM off the entry from where supernatant is discharged to the drain on the way to the Yamuna.

III. **Ground waters sampling stations**

1. A Hand pump, just near the ash pond.

Contd.......

2. A Hand pump, 20 metre away from the ash pond.

3. A Hand pump, in the premises of the pump house.

4. A Hand pump, at the tea stall near the village of Ali.

5. A Hand pump in the house of Mr. Satpal Singh.

6. A Hand pump in House No. CD-25.

7. A Hand pump in the house of Mr. Dharamvir Singh.

8. A Hand pump in the house of Mr. Khajan Singh.

9. A Hand Pump in the house of Mr. Nawab.

10. A Hand Pump in the house of Mr. Prem Das Premi.

Contd.......

11. A Hand Pump in the upper part of the house of Mr. Joshi.

12. A Hand Pump in the lower part of the house of Mr. Joshi.

13. A Hand Pump in the house of Mr. Ram (H.No. 48).

14. An open Dug Well in the house of Mr. Ram Chandra.

15. A Hand Pump in the house of Mr. Het Ram.

16. A Hand Pump in the house of Mr. Shiv Charan.

17. A Hand Pump in the house of Mr. Veeru.

18. A Hand Pump in the house of Mr. Nenu.

19. A Hand Pump in the house of Mr. Anand.

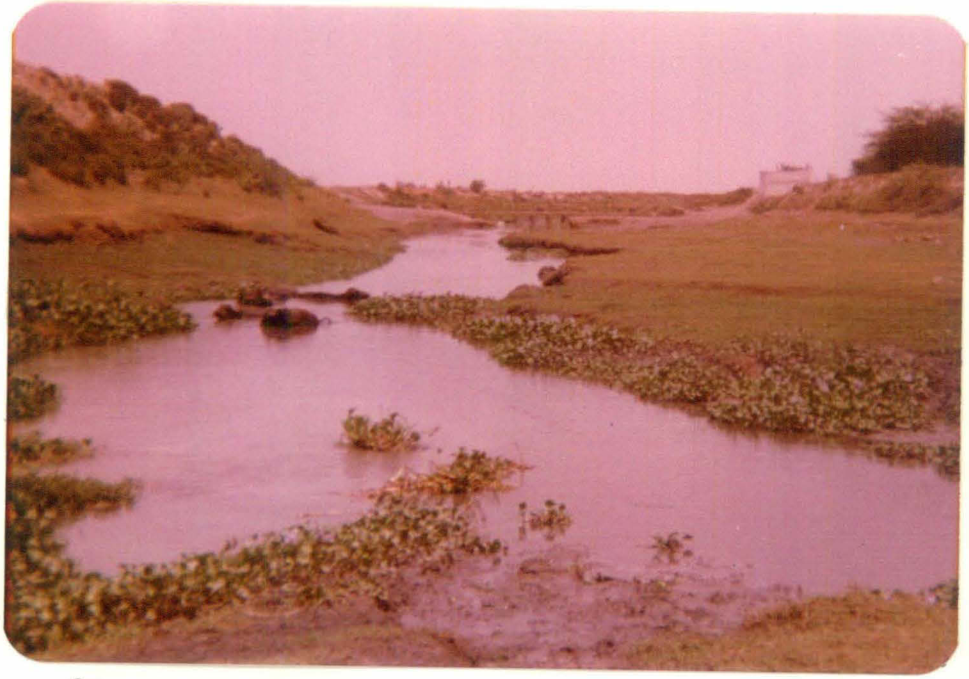
20. An open Dug Well fitted with the wind mill near the nursery.

Contd.......

STATION NO. 1 OF PARTIALLY TREATED SEWAGE

STATION NO. 2 OF PARTIALLY TREATED SEWAGE

STATION NO. 3 OF PARTIALLY TREATED SEWAGE



STATION NO. 4 OF PARTIALLY TREATED SEWAGE

STATION NO. 14 OF GROUND WATER (OPEN DUG WELL)

STATION NO. 20 OF GROUND WATER (OPEN DUG WELL FITTED WITH WINDMILL)

STATION NO. 1 OF ASH POND.

STATION NO 2 OF ASH POND.

STATION NO. 3 OF ASH POND.

STATION NO. 4 OF ASH POND.

STATION NO. 16 OF GROUNDWATER (H.P.)

STATION NO. 17 OF GROUNDWATER (H.P.)

STATION NO. 1 OF GROUNDWATER.

STATION NO. 5 OF GROUNDWATER

The water samples from all the above 28 sites were, periodically once a month, collected and analysed for the following parameters.

1. **Physico - chemical parameters:**

   pH, EC, COD, Alkalinity, Hardness, Chloride, Sulphate, Phosphate, Nitrate, Nitrite, Silica, TDS, Fluoride and Potassium.

2. **Heavy metals/Trace elements**

   Pb, Zn, Cu, Fe, Mn, Cd and Ni

3. **Bacteriological examination**

   MPN/100 ml value of total coliform bacteria.

The methods are dealt in detail below.

Methods

Chemical Parameters

Contd.......

The procedures outlined by APHA AWWA (1980) were followed in estimation of different physico chemical parameters.

1. pH

pH of the sample was determined in situ by portable pH meter.

2. EC

Systronics - 303 direct reading EC meter was used.

3. Alkalinity

Following reagents were used

a. Methyl Orange Indicator
b. Phenolphthalein Indicator
c. Sodium Carbonate - 0.1 N
d. Sulphuric Acid - 0.02N

Procedure:-

Contd.......

50 ml of the sample was taken in a conical flask and was added two drops of phenolphthalein indicator and titrated against 0.02N H_2SO_4 to a colourless end point.

P-alkalinity (as $CaCO_3$) in ppm.

$$= \frac{A \times N \times 50,000}{\text{ml. sample}}$$

Where A = Volume of H_2SO_4 consumed

N = Normality of H_2SO_4

M - Alkalinity

The same procedure was repeated with Methyl Orange indicator to the end point from yellow to faint orange.

$$\text{M - Alkalinity (ppm)} = \frac{A \times N \times 50,000}{\text{ml sample}}$$

Hardness

The following reagents were used.

a. Buffer Solution
b. Erichrome Black T

Contd.......

c. Murex Indicator

d. Standard EDTA Solution

Procedure

Appropriate volume of the sample was transferred to a conical flask adding 1-2 ml of buffer solution and 1 ml inhibitor and then titrated against standard EDTA solution.

$CaCO_3$ hardness (ppm)

A X B X 1000

ml sample

where, A = ml of titration for sample

B = ml of $CaCO_3$ eqv. to 1.00 ml of EDTA.

Chloride

Chloride content in samples was estimated by argentometric method.

Reagents

a. Standard Silver Nitrate Solution 0.0141 N

Contd.......

b. Potassium Chromate Indicator.

Procedure

A known volume of sample was titrated against $AgNO_3$ solution K_2CrO_4 as the indicator. End point was marked by the appearance of brick red colour. A reagent blank was also titrated simultaneously.

$$\text{Chloride (ppm)} = \frac{(A-B) x N x 35,450}{\text{ml. sample}}$$

where A = ml. $AgNO_3$ for sample

B = ml. $AgNO_3$ for Blank

N = Normality of $AgNO_3$.

Nitrate

Reagents

a. Ammonium Hydroxide

b. Potassium Hydroxide - 12 N KOH

c. Standard Nitrate Solution - 1 ml = 10 ug

d. EDTA Solution

Contd.......

Procedure

The sample was evaporated to dryness on a water bath and the resulting turbidity was dissolved by adding EDTA dropwise. Volume was finally made to 50 ml. A reagent blank was prepared in the same way and the absorbance read at Shimadzu spectrophotometer at 410 nm. A calibration curve using standard NO_3 solutions was prepared in the concentration sample of 5-500 mg/l. Then nitrate levels of samples were drawn from it.

Nitrite

Reagents

a. EDTA reagent.
b. Sulphanilic Acid
c. Sodium buffer
d. Standard NO_2 Solution - 1 ml = 0.5 ug

Procedure

A suitable volume is sample was neutralised to pH 7.0. To this 1 ml. of EDTA amd 1 ml.

Contd.......

of sulphanilic acid were added and mixed. After 2-3 minutes 1 ml. 1-Naphthyl ethyl diamine dihydrocholoride and 1 ml sodium acetate were added and shaken well. The colour developed was read at 520 nm in Shimadzu Spectrophotometer. Blank and a series of standards were obtained in a similar way to prepare the calibration curve from which the concentration of nitrite in the samples was determined.

Sulphate

Regents

a. Barium Chloride - Crystals

b. Standard Sulphate Solutions - 1 ml = 100 ug SO_4

Procedure

To a suitable volume of sample 5.0 ml conditioning reagent was added and mixed. While stirring the mixture with magnetic stirrer, a pinch of $BaCl_2$ crystals were added and the stirring continued for 2-3 minutes. Turbidity was measured with the help of

Contd.......

Shimadzu spectrophotometer at 420 nm. Standard calibration curve was prepared as sulphate solutions of range 0-100 mg/l and sample values were determined from the curve.

Sulphate was calculated as follows :

$$SO_4 \text{ mg/l} = \frac{MgSO_4 \times 1000}{\text{ml. sample}}$$

Silicates

For its determination, hetero poly blue method was followed.

Reagents

a. **Ammonium Molybdate**

b. **Hydrochloric Acid**

c. **Oxalic Acid**

d. **Reducing Agent - (ANSA)**

e. **Standard Suitable Solution - 1 ml = 10 ug**

Procedure

Contd.......

To a suitable aliquot of sample 1 + 1 HCl (v/v) was added followed by 2 ml. ammonium molybdate. After 5-10 minutes 1.5 ml. Oxalic acid and 2 ml. reducing agent were added and the volume made 100 ml. The colour developed was measured at 690 nm after 10 minutes with the help of Shimadzu spectrophotometer.

A reagent blank and a series of standard silicate concentrations were prepared to give a calibration curve. Samples silicate contents were computed from the standard calibration curve.

Chemical Oxygen Demand

Reagents

a. Standard Potassium Dichromate (0.25N)
b. Ferrous Ammonium Sulphate (0.25 N)
c. Silver sulphate solution
d. Ferroin indicator
e. $HgSO_4$

Procedure

Contd.......

0.59 g $HgSO_4$ was placed in a reflux flask and 20 ml. of the sample was added and mixed well. Then 10 ml. of standard Ag_2SO_4-$K_2Cr_2O_7$ soln. and 30 ml of Ag_2SO_4 - H_2SO_4 mixture were added to the sample in the flask. The contents were refluxed for two hours. Then each flask was allowed to cool and then washed with 80 ml. distilled water. The excess of dichromate was titrated against standard FAS soln. using ferroin indicator. Sharp colour change from blue green to wine red indicated the end point.

Two reagent blanks were also refluxed in the above manner.

Calculation

$$\text{COD mg/l} = \frac{(a-b) \times N \times 8000}{\text{ml. sample}}$$

Where

a = ml. of FAS consumed for blank.

b = ml. of FAS consumed for sample.

N = normality of FAS.

Contd.......

Fluoride

Fluoride being a very important parameter of drinking water needs utmost precision in its determination and that´s why Orion Ionalyzer 901 was employed for fluoride assessment using the fluoride electrode and low level TISAB as recommended by the manual supplied by the company.

Phosphate

The phosphate estimation in ground water was done by Bragg and Kurtz solution method.

Reagents

a. Standard stock phosphate solution : 1000 ppm.
b. Working Stock Standard : 100 ppm
c. Bragg´s and Kurtz Reagent.

Procedure

The blue colour developed was measured in Shimadzu Spectrophotometer. The calibration

Contd.......

curve was obtained with the help of blank reagent and standard PO_4 in ppm was calculated as follows :

x X ml sample

where

x = slope of the graph

Metals Estimation

AAS method was used for this purpose. The GBC scientific equipment PTY. Ltd. Model 902, AAS was employed.

Bacteriological Examination of Water

Total Coliform count

Most probable number (MPN/100 ml) tests underlined in APHA - AWWA WPCF (1980) were followed for determination of total coliform density in water samples. The test comprises of following three steps :

I. Presumptive Test

Contd.......

Lactose broth

Beef extract	3.0 g
Peptone	5.0 g
Lactose	5.0 g
Distilled Water	1000 ml

Double strength broth

All the above said quantities were dissolved in 500 ml. of distilled water. pH was adjusted between 6.8-7.0

Procedure

10 ml of the medium (single and double strength separately) was added in fermentation tubes and inverted Durham´s tubes were placed in each tube. Tubes were then covered with cotton plugs. Sterilisation of the tubes were done at 15 lbs. pressure and 120 C temperature for 15 minutes in an autoclave.

Contd.......

Five of the double strength tubes were inoculated with 10 ml. portions of the sample and five each of the single strength tubes were inoculated with 1 ml. and 0.1 ml. portions of the samples. Incubation of the inoculated tubes were done at 35+0.5 C for 24+2 hrs. All the tubes showing no gas evolution were replaced back for further incubation and the tubes that showed positive results for presumptive test were recorded and were proceeded with the confirmed test.

Absence of gas at the end of 48+3 hrs. of incubation was indicative of negative test.

II. Confirmatory Test

Brilliant green lactose bile broth (BGLB) was used for the confirmed test.

Procedure

Contd.......

Medium was dissolved by heating and 7 ml. of the medium was dispensed in each of the fermentation tubes. After addition of the Durham´s tubes, sterilisation of the fermentation tubes was done at 15 lbs. pressure for 20 min.

Three tubes out of the set of five positive presumptive tubes were confirmed in BGLB broth by transferring the inoculum to BGLB the same day they have shown positive for presumptive test. Inoculated BGLB tubes were incubated at 35+0.5 C for 48+3 hours. Gas production showed the presence of a positive confirmation of coliform presence.

III. <u>Complete Test</u>

Eosin Methylene Blue (EMB) Agar was used for the purpose.

Composition of the EMB Agar Medium :

Contd.......

Peptone	10.0 g
Lactose	10.0 g
K_2HPO_4	2.0 g
Agar	15.0 g
Eosin Y	0.4 g
Methylene Blue	0.065 g
Distilled Water	1000 ml.

pH was adjusted to 7.1 after sterilisation.

The media was poured into sterilised petridishes and cooled to solidify.

Procedure

Inoculum from positive confirmed tube was streaked out on the EMB agar. Plates were incubated at 35+0.5 C for 24 hours. The confirmation of coliform colonies was achieved through a careful observation of the following characteristics :

i) Appearance of colonies - the typical colonies belonging to coliform group showed a green sheen.

Contd.......

ii) From each of the plate one or more than one of the typical colonies were picked up and transferred to lactose broth containing Durham´s tubes incubated at 35+0.5 C for 24 hours. Evolution of gas confirmed the colonies to be of coliform.

iii) Gram-negative test : Colonies of coliform were picked up and gram staining test was performed, to confirm the gram reaction, as outlined by Seeley and Van Demark (1975). Total coliform number was found by reference to a standard MPN table (Appendix).

Contd.......

RESULTS

OBSERVATION

Results

The results of the present investigations have been incorporated in three break ups for every parameters assessed. The first one deals with the partially treated sewage water, second one deals with the slurry water and the third one deals with the ground water.

The emphasis in primarily on the quality of the ground water in terms of potability vis-a-vis the drinking water standards. The results pertaining to the load of pollutants, the partially treated sewage water and the slurry water only serve as an inventory of informations for explaining the possible causes of contamination of the ground water, if need be.

pH

pH readings of all the 20 ground water samples of the 18 hand pumps and 2 open wells

Contd.......

show a slight acidic nature of the water. The variation in values of pH ranges from 6.8 to 7.5. There are two wells i.e. station nos. 11 and 18 whose average values of pH are 6.92 and 6.80 respectively. But the monthly variation of pH of the same wells shows that pH is a subject of specific climatic parameters and changes slightly with the change of climatic constituents. However, pH is within the prescribed limit of potable water criteria (vide, appendix).

Electrical Conductivity (EC)

The average value of EC varies between the limits of 128 and 185 micro mhos/cm. The seasonal variation is wide from well to well. In the case of station no. 14 (i.e open dug well) the seasonal variation of EC is 116.60 to 168.0 micro mhos/cm from February to April showing the increase in value of EC along with the temperature. But all the sampled don´t show any definite relationship of EC with the months because EC is dependent on a host of variables.

Contd.......

Total Alkalinity

The p-alkalinity in all cases were found to be zero. The average value of alkalinity of ground water samples varies from 173 to 506.7 of the alkalinity is also appreciable. It is evident from the station no. 13 where the alkalinity varies from 340 to 425 from February to April. The highest alkalinity is 506 ppm in case of well no. 5.

Chemical Oxygen Demand (COD):

The organic constituents in ground water samples are almost negligible and usually yield the experimental value zero. But in case of station no. 3 which is situated very near to pump house where the partially treated sewage water is stored and station no. 1 which is just at the bank of the ash pond, show a little value of COD of 4 to 8 ppm suggesting a part of chemical constituents from the sewage and slurry waters penetrating there. The small values of COD in case of open dug wells suggest the

Contd.......

fall out of organic matters there from the outside.

Total Hardness:-

The total hardness varies from 180 to 644.0 ppm from station to station. However, the seasonal variation in case of individual wells are also appreciable. The station no. 2 recorded minimum value and station no. 15 recorded the maximum value. However, the permissible limit of hardness (as $CaCO_3$)is prescribed to be 500 ppm and station no.15 is the only source of water which is objectionable from this point of view. However, the total hardness is a parameter which seems to be determined by the source characteristics rather than being influenced by other factors.

Chloride:

The chloride values vary widely from well to well and the seasonal variation is smaller in comparison. The maximum and minimum limits of chloride are 40.06 to and 518.60 ppm. The

Contd.......

chloride content of ground water seems to be maximum in the middle of the village whereas the eastern and western fringe of the village show low level of chloride content in the ground water.

The hand pump no. 7, however, yields water which is beyond the permissible limit in chloride (vide, WHO appendix). The water samples from the station nos. 6,9, 10, 11, 12, 13, 14, 15 contain chloride beyond the maximum desirable limit of that (vide, WHO appendix).

Nitrate

The average values of nitrate vary from 1.3 to the exceptional value of 136.0 ppm. Otherwise the general trend is 1.32 to 20 ppm in most of the cases. However, here also the ground water samples from the middle of the village show greater concentration of nitrate while in the case of the two ends of the village, water samples show lesser concentration of the nitrate i.e. 1 to 10 ppm.

Contd.......

Nitrite

The average values of nitrite varies from 1.63 to 13.9 ppm and here also the concentration of nitrite in the ground water samples of the middle of the village show higher values than the two ends of the village.

Phosphate

The average value of phosphate ranges from 0.25 to 1.37 ppm. In most of the cases the phosphate content is beyond the maximum acceptable level.

The water samples from the station nos. 1, 2, 3 and 15 show the heavy contamination of phosphate but this contamination may be attributed to neither slurry nor sewage water though they are rich in phosphate because some hand pumps i.e. 10, 15 etc, showing high content of phosphate are quite far off from them.

Contd.......

Sulphate

The average value of sulphate varies from 95.4 to 278.8 ppm from well to well. The seasonal variation is appreciable but does not follow any definite trend. Most of the values are well below the desirable limit and a few are near of it.

Silicate

The average value of silicate varies from 6.5 to 46.3 ppm. The silicate value is an indicative of the nature of the rock/soil of the aquifer and its degree of weathering etc.

Fluoride

The average value of fluoride varies from 0.223 to 1.54 ppm from well to well. The seasonal variation is small. However, station nos 10, 13 and 20 contain fluoride in more than the prescribed limit of 1.0 ppm. Some samples show the fluoride concentration very near to the dangerous level of 1.0 ppm

Contd.......

as station nos. 6,9, 12 and 16 whose fluoride concentration varies between 0.7 to 0.9 ppm.

Potassium

The average value of potassium in ground water varies from 6.42 to 31.3 ppm. The water samples from the station nos. 1, 2, 3, 4, and 17 etc. show higher values.

Total Coliform

The (MPN/100 ml) value of total Coliform bacteria varies from well to well and month to month. The open dug wells are heavily polluted in term of bacterial contamination. But the hand pumps are less polluted because of well protection from the outside. However, the water samples from the station no. 3 (in the premises of the pump house) indicate heavy bacterial pollution and may be so because of introduction/percolation of biological contaminants there from the sewage storage of nearby. As a whole, the all the samples of all the ground waters are contaminated in terms of total Coliform

Contd.......

count, though the degree of contamination varies from well to well.

Heavy Metals

Seven heavy metals were chosen to be analysed in ground water because of their high toxicity. They are Pb, Cd, Cu, Fe, Mn, Zn and Ni.

Lead (Pb)

The average value of Pb varies from 7.85 to 53.05 ppb in the samples of ground water. Here, also the specific nature of the rock of every aquifer, station-wise, plays a greater role than those of supposedly sources of contaminants namely sewage and slurry waters. All the samples show Pb concentration below the prescribed limit of 100 ppb.

Zinc (Zn)

The average valve of Zn varies from 1.03 ppb to 278.3 ppb, while the highest permissible limit is 5000 ppb. However, samples of water

Contd.......

from the station nos. 4, 9, 13 and 14 show abnormally high level of Zn.

Iron (Fe)

The average value of Fe varies from 9.81 to 319.9 ppb. However, ironically the station nos. 1, 2 and 3 which are situated near the ash pond where fly ash are rich in iron show least concentration of Fe while the stations in the middle of village show higher concentration of Fe. Except well no. 12, all values are below the ISI prescribed limit of 300 ppb.

Cadmium (Cd)

The average value of Cd varies from 0.337 to 4.29 ppb, while the ISI prescribed maximum limit is 10 ppb. The sources of ground water which are situated in the middle of the village show higher concentration of Cd.

Copper (Cu)

Contd.......

The average value of Cu varies from 1.29 to 11.11 ppb, while WHO maximum permissible limit is 50 ppb. Here again the ground water samples from the middle of the village show higher concentration of Cu.

Manganese (Mn)

The average value of Mn of ground water samples varies from 1.27 ppb to 214.8 ppb while the maximum permissible limit of Mn is only 50 ppb. Hence the station nos. 9, 10, and 17 are unsafe for drinking purposes from the view point of Mn contamination.

Nickel (Ni)

The average value of Nickel in ground water varies from 3.04 to 14.94 ppb. which seems to be within the reasonable limit because its toxicity is still not well understood and hence, its permissible limit not ascertained.

Contd.......

pH OF PARTIALLY TREATED SEWAGE AT VARIOUS STATIONS OF FLOW

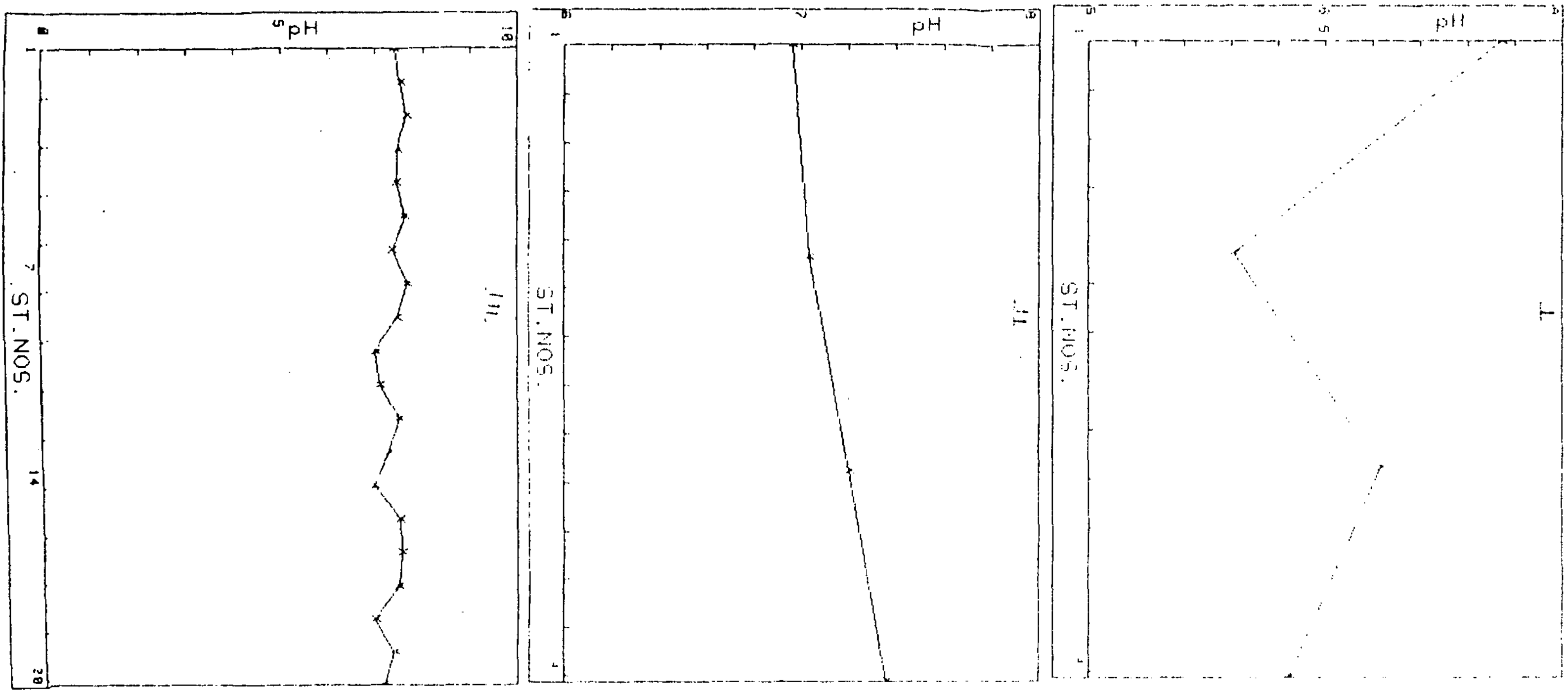
Stations	Period Feb	Mar	Apr	Average
1.	6.96	7.10	7.20	7.1±0.12
2.	7.03	7.36	7.20	7.2±0.2
3.	7.20	7.40	7.25	7.3±0.10
4.	7.36	7.40	7.03	7.3±0.20

pH OF SLURRY AT DIFFERENT POINTS OF A ASH POND

Stations	Period Feb	Mar	Apr	Average
1.	7.62	6.21	7.05	6.96±0.70
2.	5.92	6.30	6.80	6.34±0.44
3.	6.85	6.72	6.82	6.80±0.07
4.	6.27	6.85	7.05	6.72±0.41

pH OF GROUND WATER AT VARIOUS STATIONS

Stations	Period			Average
	Feb	Mar	Apr	
1.	7.90	7.20	7.10	7.40±0.5
2.	8.00	7.30	7.25	7.52±0.4
3.	7.68	7.80	7.50	7.66±0.2
4.	7.70	7.20	7.50	7.47±0.3
5.	7.65	7.50	7.20	7.45±0.23
6.	7.85	7.50	7.48	7.61±0.21
7.	7.60	7.30	7.20	7.37±0.2
8.	7.71	7.50	7.80	7.67±0.2
9.	7.68	7.50	7.20	7.46±0.2
10.	7.08	7.00	6.92	7.00±0.1
11.	6.98	7.10	7.20	7.10±0.1
12.	7.80	7.20	7.5	7.50±0.3
13.	7.50	7.20	7.10	7.30±0.21
14.	6.90	7.10	7.01	7.00±0.10
15.	7.50	7.20	7.90	7.53±0.40
16.	7.90	7.60	7.20	7.57±0.40
17.	7.60	7.50	7.40	7.50±0.1
18.	7.2	6.90	6.80	7.0±0.21
19.	7.02	7.50	7.70	7.41±0.3
20.	7.20	7.10	7.30	7.2±0.1

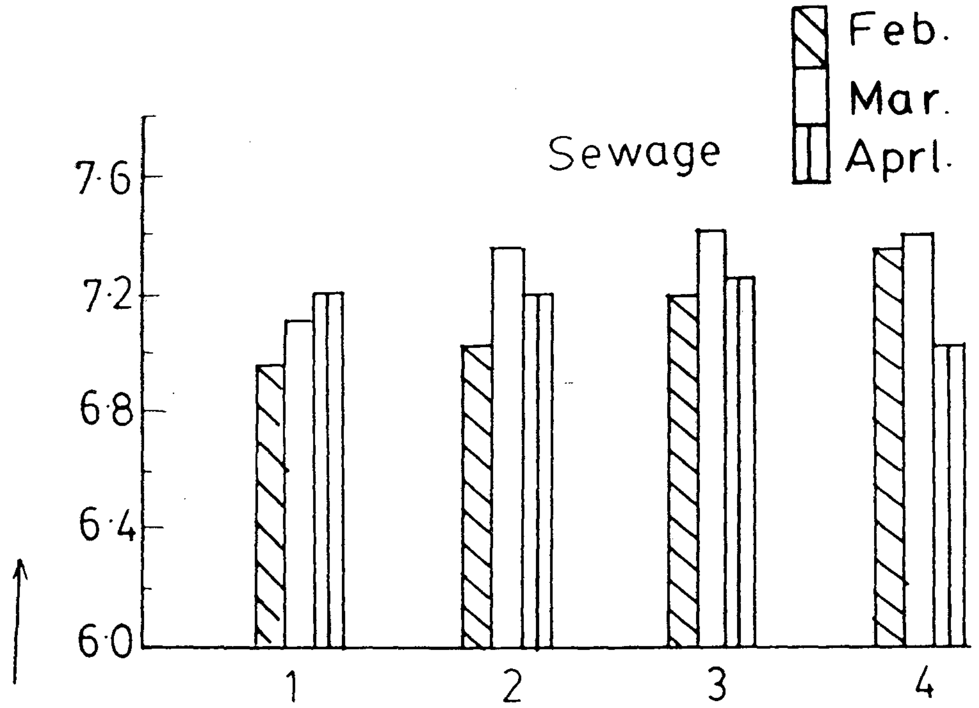


AVERAGE VALUE OF pH IN SAMPLES

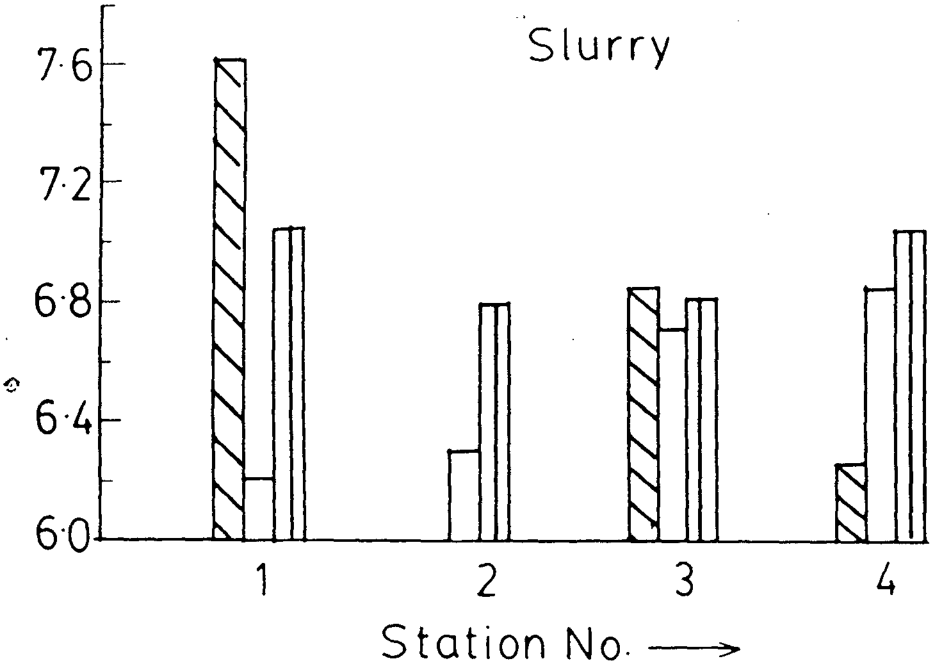
I - Samples of partially treated sewage

II - Samples of slurry water

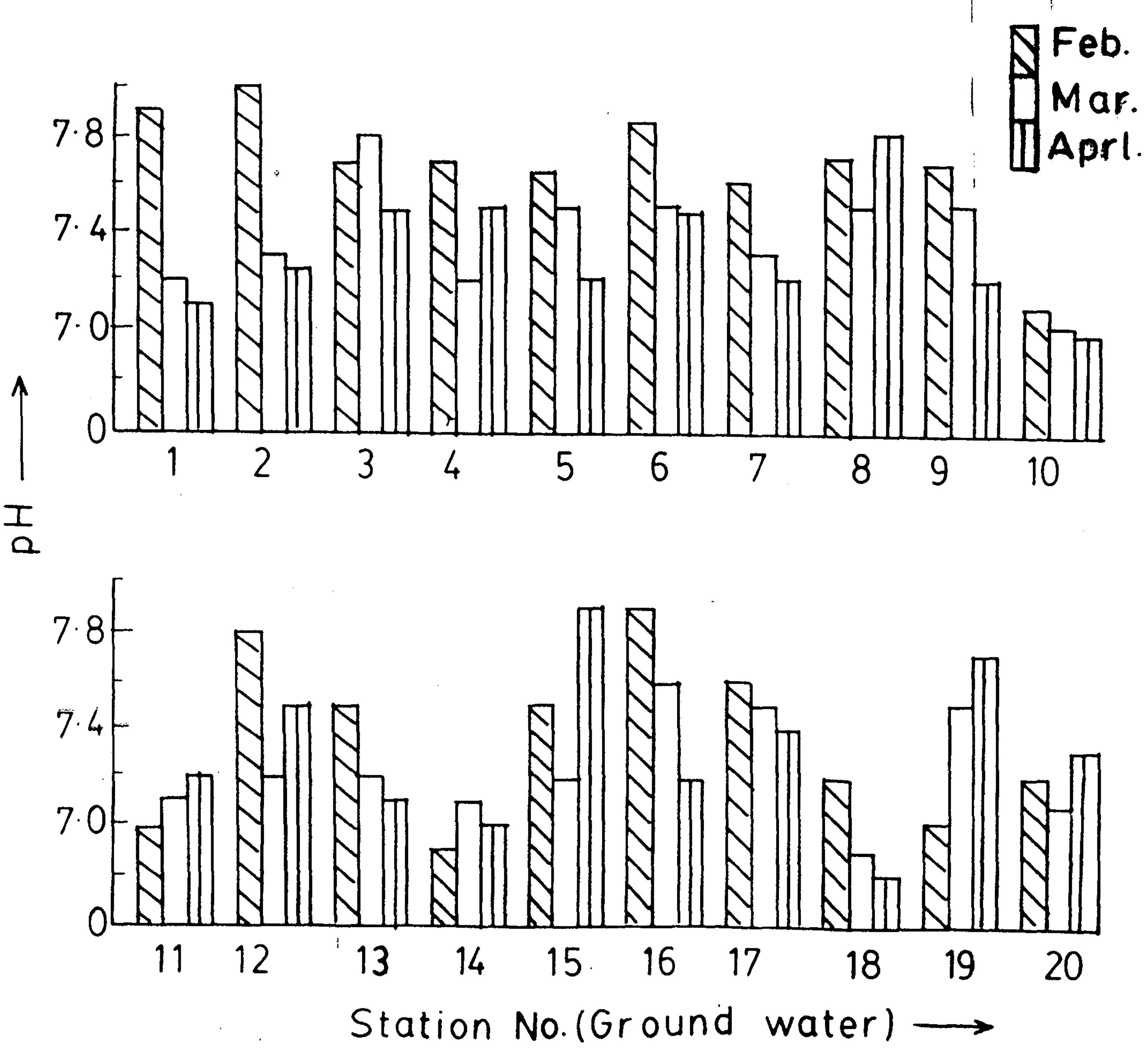
III - Samples of ground water



15.a. Periodical variation of pH in partially treated sewage samples collected from different stations.



15.b. Periodical variation of pH in slurry water collected from different stations.



15.c. Periodical variation of pH in groundwater collected from different stations.

EC OF PARTIALLY TREATED SEWAGE AT VARIOUS STATIONS OF FLOW

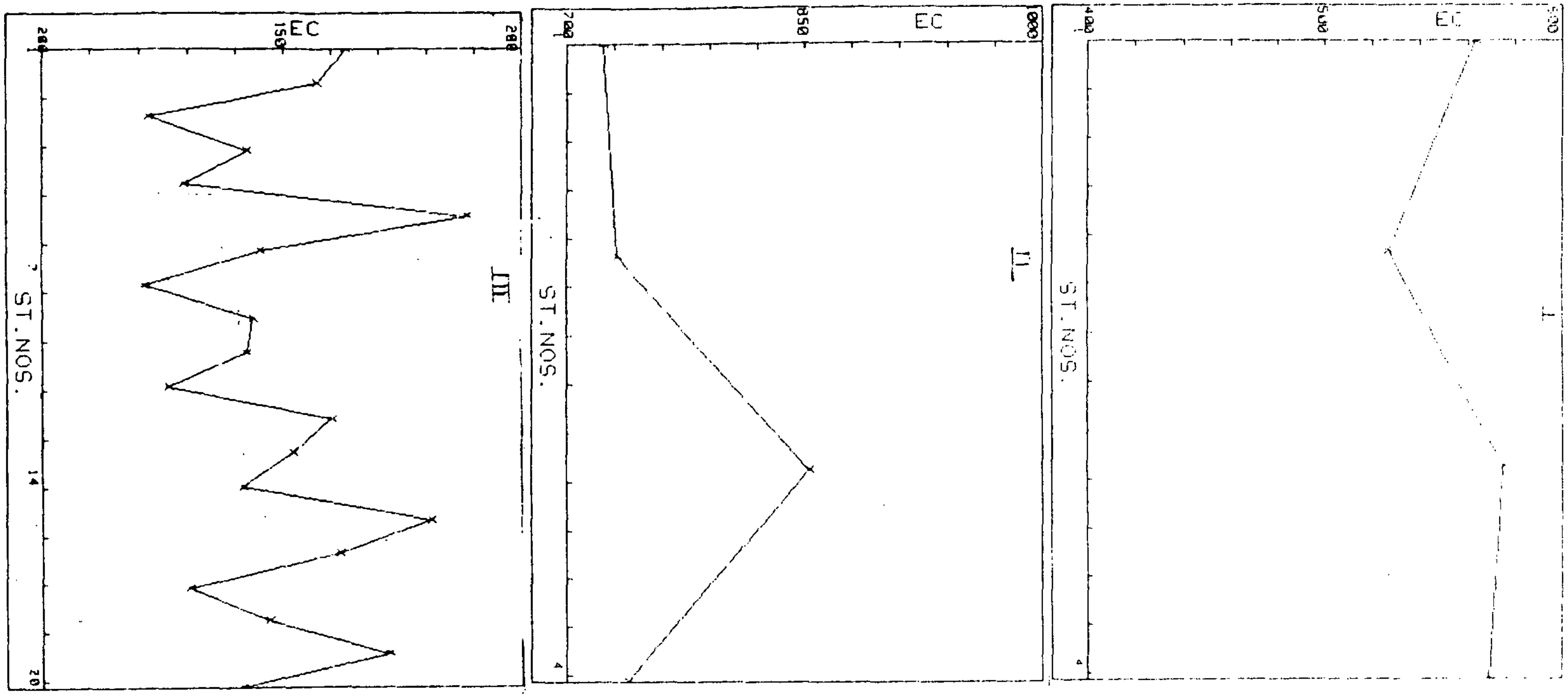
Stations	Period Feb	Mar	Apr	Average
1.	570.2	568.1	550.8	563.0±10.6
2.	510.2	520.8	548.6	526.5±19.8
3.	548.2	580.0	596.3	574.8±24.5
4.	596.3	588.8	520.8	568.6±41.6

EC OF SLURRY AT DIFFERENT POINTS OF A ASH POND

Stations	Period Feb	Mar	Apr	Average
1.	626.0	770.2	770.6	722.2±83.4
2.	770.6	688.6	736.0	731.7±41.2
3.	880.6	788.6	888.6	852.6±55.6
4.	776.25	682.6	756.0	738.3±49.3

EC OF GROUND WATER AT DIFFERENT STATIONS

Stations	Period Feb	Mar	Apr	Average
1.	170.6	168.0	150.0	162.90±11.2
2.	175.4	145.3	150.6	157.10±16.1
3.	116.00	120.0	130.0	122.0±7.2
4.	148.52	128.0	150.8	142.5±12.6
5.	128.80	130.0	128.8	129.20±0.7
6.	199.4	180.6	185.4	188.50±9.8
7.	158.0	150.8	126.9	145.20±16.3
8.	125.0	120.5	118.0	121.20±3.5
9.	140.25	122.8	168.0	143.70±22.8
10.	136.40	140.6	150.2	142.40±7.1
11.	116.60	120.6	140.8	126.0±13.0
12.	168.80	168.6	142.6	160.0±15.1
13.	146.50	150.8	158.8	152.0±6.2
14.	116.60	140.0	168.0	141.50±25.7
15.	180.60	180.0	182.4	181.0±1.25
16.	188.60	156.0	140.6	161.70±24.5
17.	125.60	120.6	148.6	131.60±14.9
18.	175.88	148.6	116.60	147.0±29.7
19.	168.00	168.5	180.0	172.20±6.8
20.	155.60	140.8	128.0	141.50±13.8



AVERAGE VALUE OF EC IN SAMPLES

I	-	Samples of partially treated sewage
II	-	Samples of slurry water
III	-	Samples of ground water

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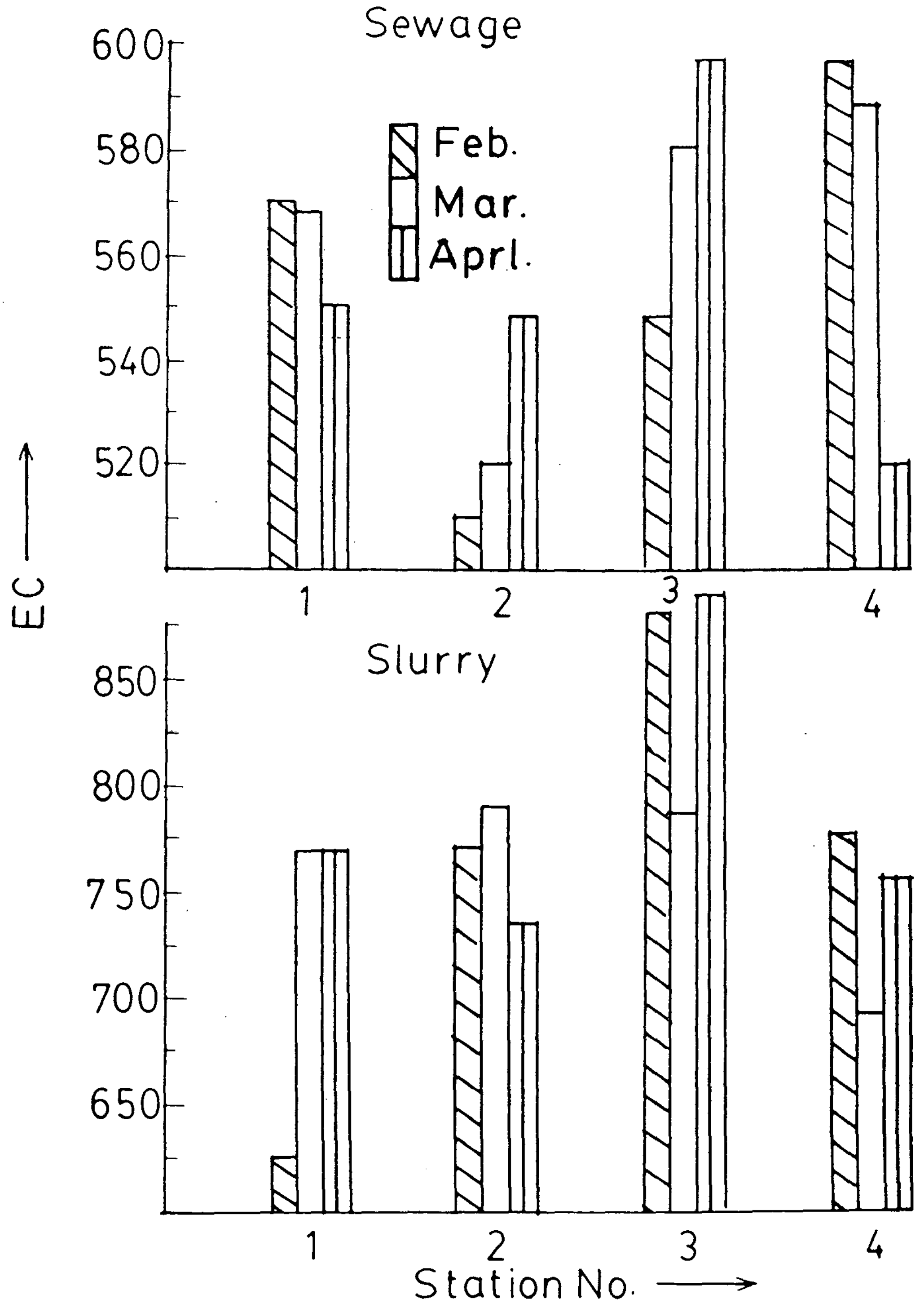
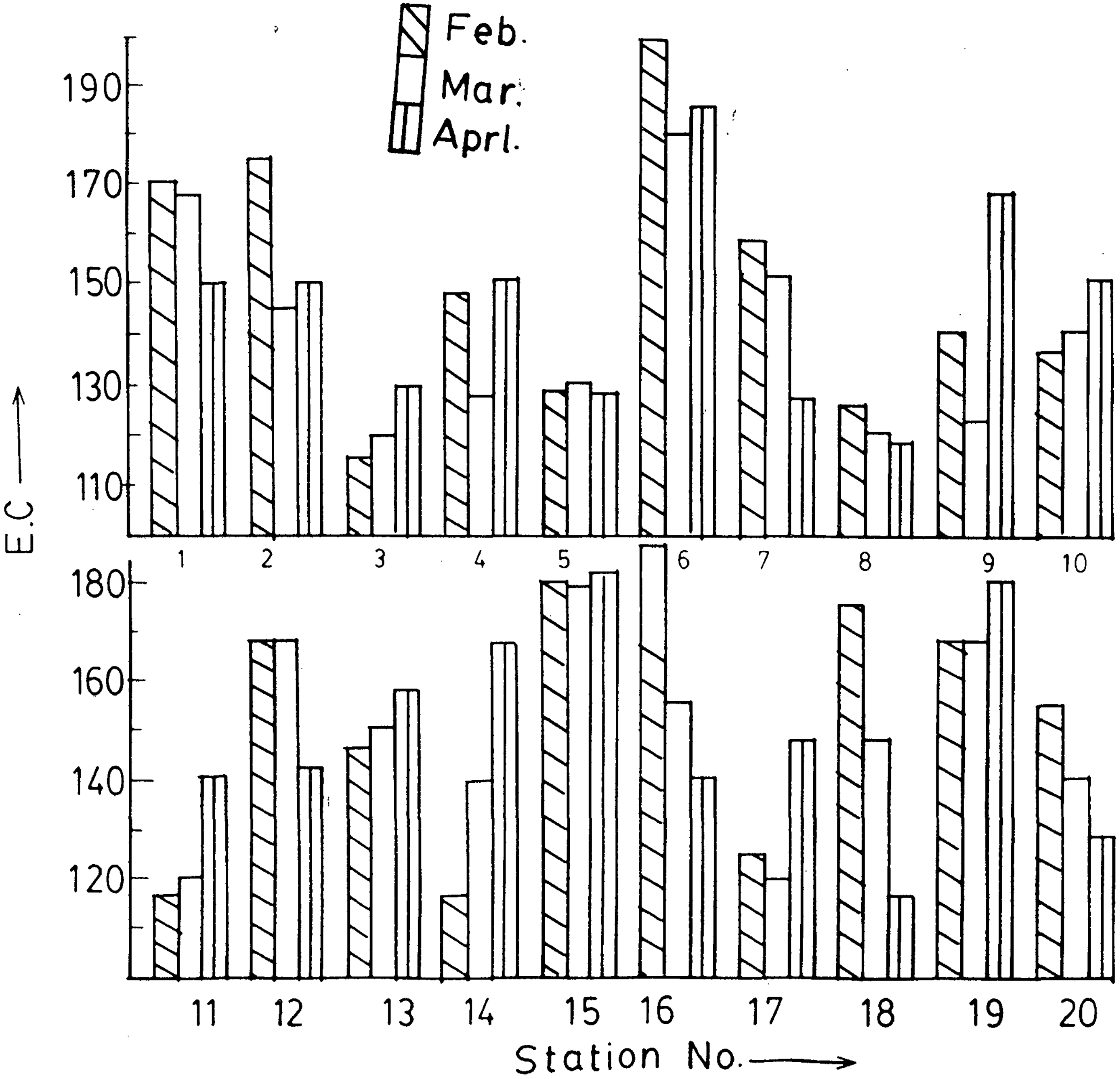
sewage water collected from different stations.



16.b. Periodical variation of EC in slurry water collected from different stations.



16.c. Periodical variation of EC in groundwater collected from different stations.

TOTAL ALKALINITY OF PARTIALLY TREATED SEWAGE FLOW AT DIFFERENT STATIONS

[In ppm]

Stations	Period Feb	Mar	Apr	Average
1.	340	388	356	361.3±24.4
2.	290	300	302	297.3±6.4
3.	300	318	340	319.3±20.0
4.	160	168	159	162.3±4.9

TOTAL ALKALINITY OF SLURRY AT DIFFERENT STATIONS OF THE SLURRY POND

[In ppm]

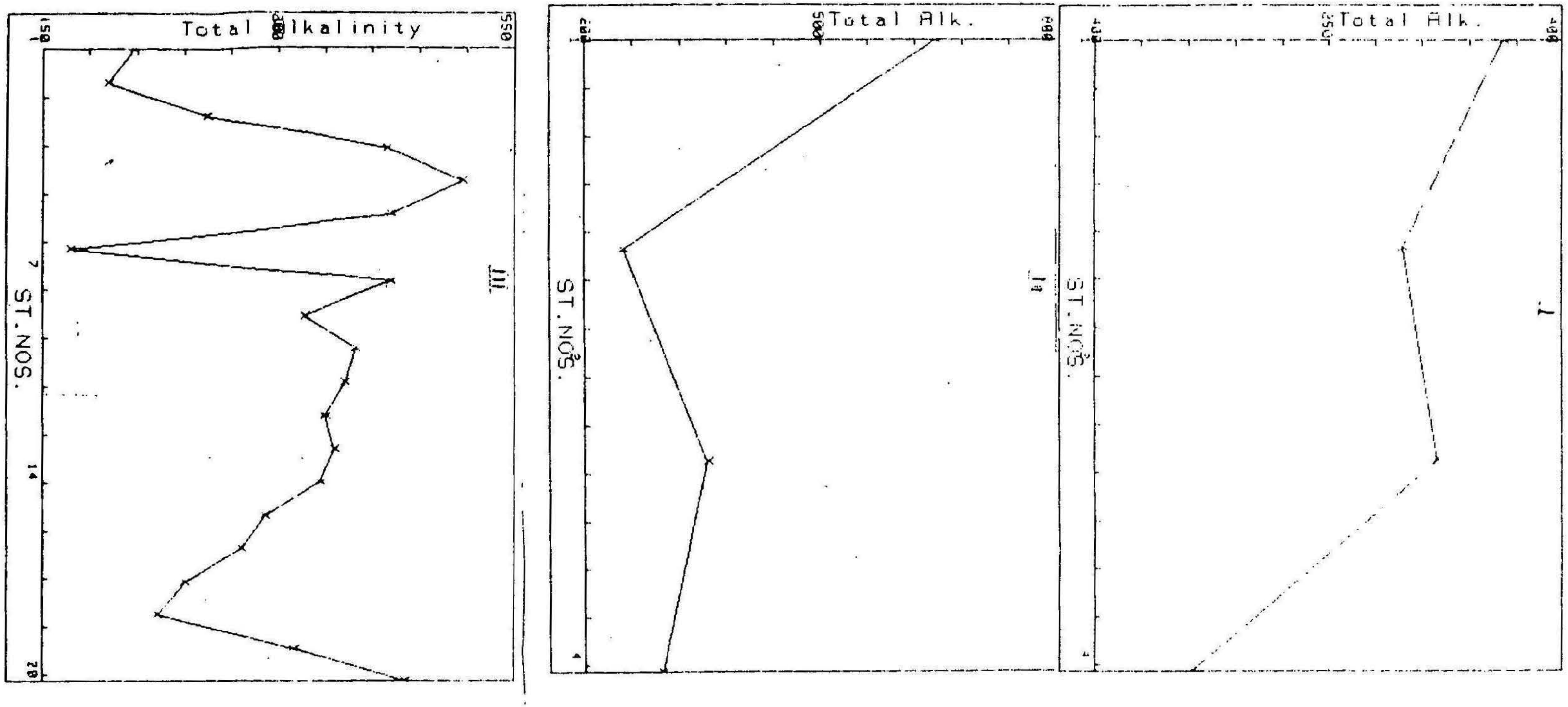
Stations	Period Feb	Mar	Apr	Average
1.	620	620	620	620
2.	150	160	162	157.3±6.4
3.	260	293	293	287±19.1
4.	150	207	288	215.0±69.3

TOTAL ALKALINITY OF GROUNDWATER FROM DIFFERENT STATIONS

[In ppm]

Stations	Period			
	Feb	Mar	Apr	Average
1.	230	240	210	226.7±15.3
2.	200	210	206	205.3±5.0
3.	290	296	282	289.3±7.0
4.	450	488	390	442.7±49.4
5.	460	472	588	506.7±70.7
6.	410	498	428	445.3±46.5
7.	160	168	192	173.3±16.7
8.	400	468	468	445.3±39.3
9.	370	376	368	371.3±4.2
10.	400	416	428	414.7±14.0
11.	390	412	416	406.0±14.0
12.	350	358	368	358.7±9.0
13.	340	425	425	396.7±49.1
14*.	320	346	398	354.7±39.7
15.	310	320	386	338.7±41.3
16.	320	320	316	318.7±2.3
17.	240	282	292	271.3±27.6
18.	380	307	356	347.7±37.2
19.	370	362	358	363.3±6.1
20*.	440	440	493	457.7±30.6

*Open Dug Wells



AVERAGE VALUE OF TOTAL ALKALINITY CONTENT IN SAMPLES [ppm]

I - Samples of partially treated sewage
II - Samples of slurry water
III - Samples of ground water

COD OF PARTIALLY TREATED SEWAGE WATER AT VARIOUS STATIONS

Stations	Period Feb	Mar	Apr	Average
1.	384	392	384	386.7±4.6
2.	232	304	392	309.3±80.1
3.	168	232	520	306.7±187.5
4.	96	168	132	132.0±36

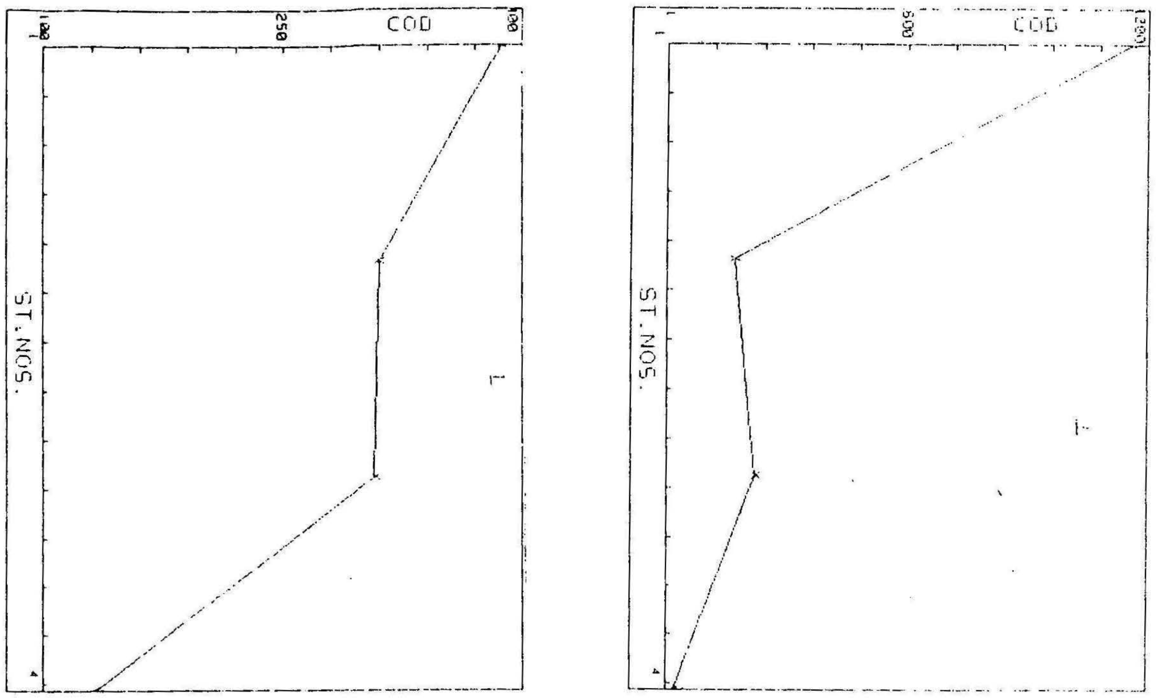
COD OF SLURRY AT VARIOUS ASH POND POINT

Stations	Period Feb	Mar	Apr	Average
1.	1384	1048	1048	1160±194.0
2.	144	132	232	169.3±54.6
3.	132	384	144	220.0±142.0
4.	16	24	24	21.3±4.6

COD OF GROUNDWATER AT VARIOUS STATIONS

Stations	Period Feb	Mar	Apr	Average
1.	8	8	8	
2.	0	0	0	
3.	4	8	4	
4.	8	8	0	
5.	0	0	8	
6.	4	0	0	
7.	0	0	0	
8.	0	4	0	
9.	0	0	0	
10.	0	0	0	
11.	0	0	4	
12.	0	0	0	
13.	0	0	0	
14*.	8	4	0	
15.	0	0	0	
16.	0	0	0	
17.	0	0	0	
18.	0	0	0	
19.	0	0	0	
20*.	8	4	8	

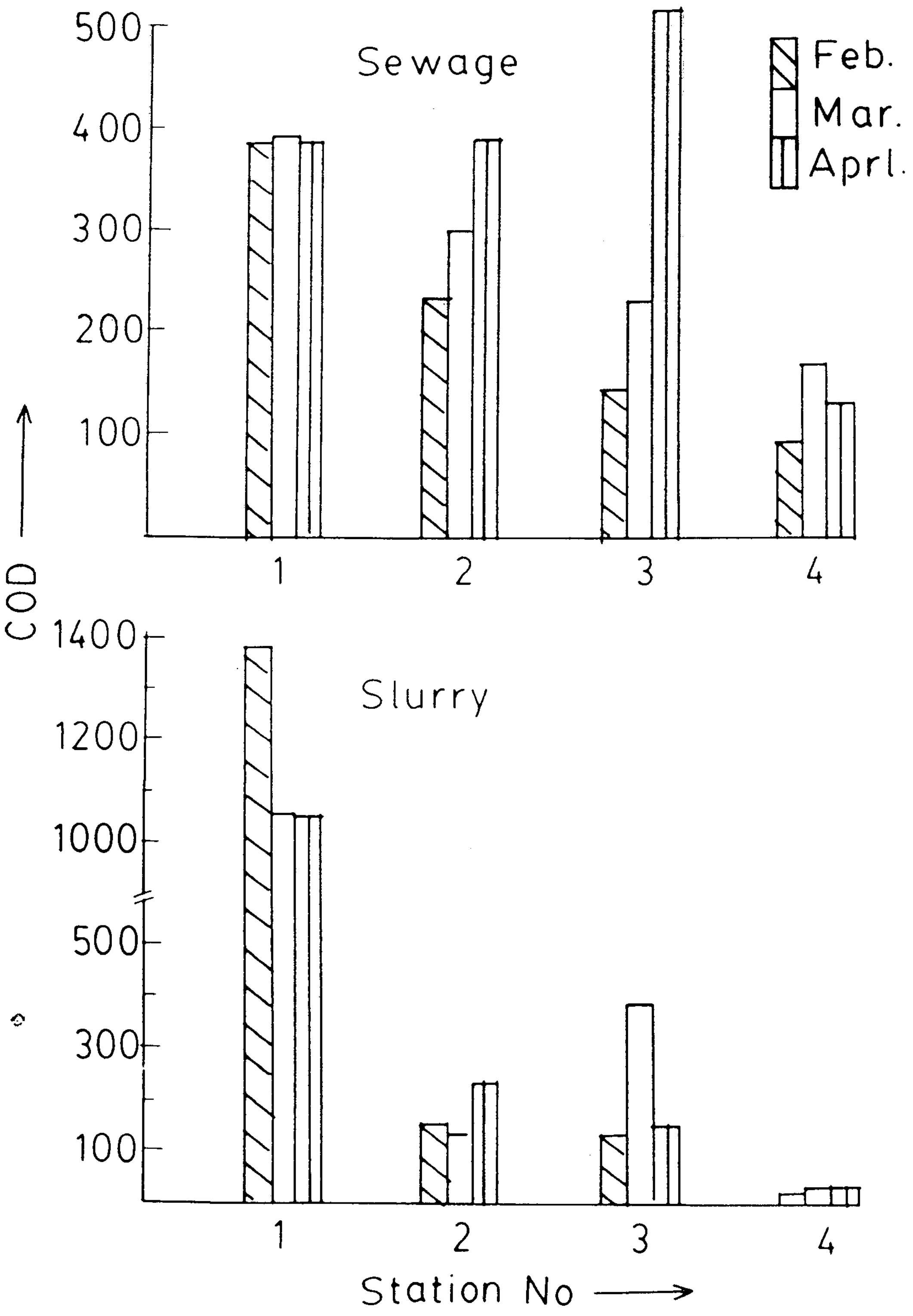
*Open Dug Wells



AVERAGE VALUE OF COD IN SAMPLES [ppm]

I - Samples of partially treated sewage

II - Samples of slurry water


Sewage
Feb.
Mar.
Aprl.
500
400
300
200
100
1
2
3
4
COD
Slurry
1400
1200
1000
500
300
100
1
2
3
4
Station No

TOTAL HARDNESS OF PARTIALLY TREATED SEWAGE WATER OF FLOW AT DIFFERENT POINTS

[In ppm]

Stations	Periods Feb.	Mar.	Apr.	Average
1.	288	240	296	274.7±30.3
2.	248	296	296	280.0±27.8
3.	280	240	224	248.0±28.8
4.	224	200	280	234.7±41.1

TOTAL HARDNESS OF SLURRY AT DIFFERENT POINTS OF THE SLURRY POND

[In ppm]

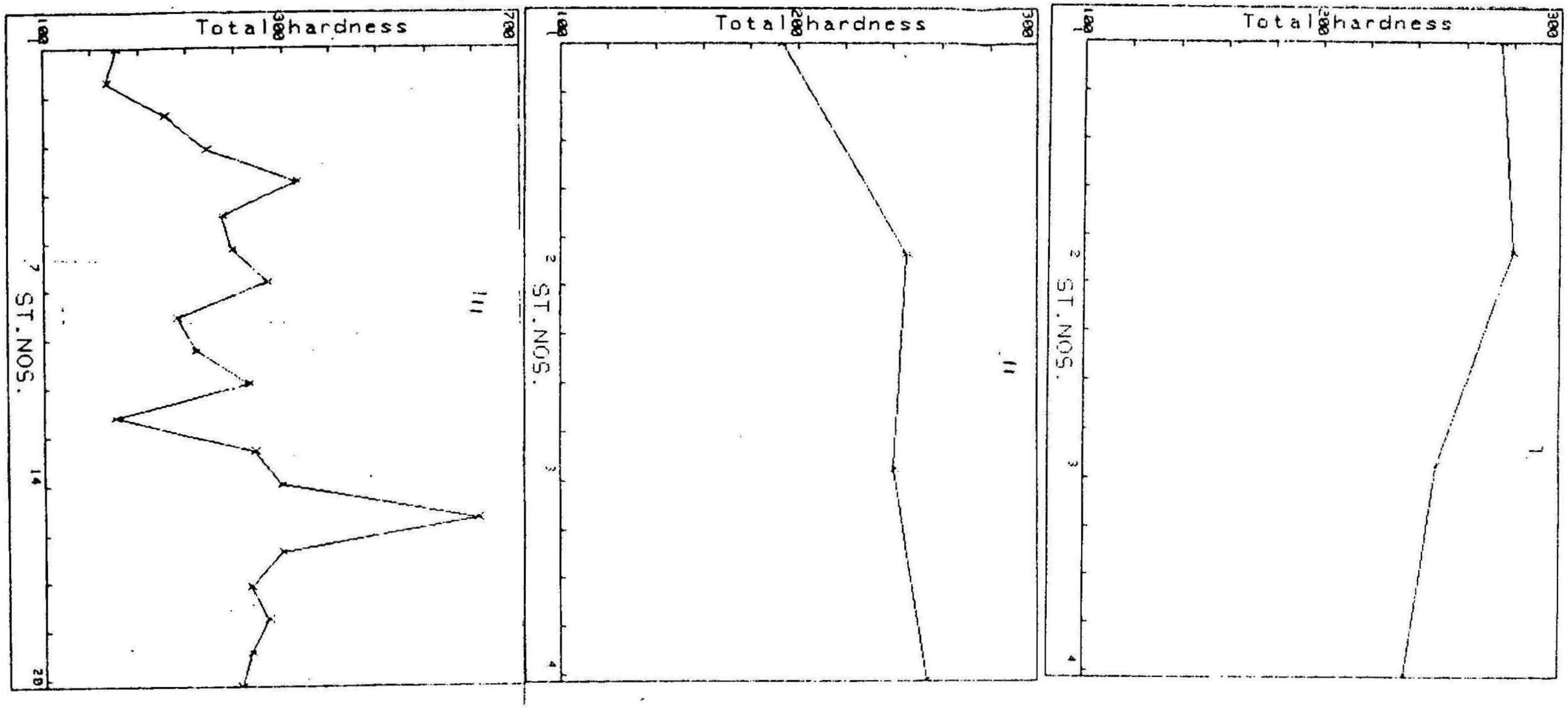
Stations	Periods Feb.	Mar.	Apr.	Average
1.	200	200	180	193.3±11.5
2.	200	240	296	245.3±48.3
3.	216	288	216	240.0±41.6
4.	240	240	280	253.3±23.1

TOTAL HARDNESS OF GROUNDWATERS FROM DIFFERENT STATIONS

[In ppm]

Stations	Periods Feb.	Mar.	Apr.	Average
1.	180	180	216	192.0±20.8
2.	180	180	180	180.0±0.0
3.	240	240	280	253.3±23.1
4.	296	296	324	305.3±16.2
5.	428	400	428	418.7±16.2
6.	324	324	324	324.0±0.0
7.	392	324	296	337.3±49.4
8.	324	392	428	381.3±52.8
9.	248	308	248	268.0±34.6
10.	272	296	308	292.0±18.3
11.	308	364	400	357.3±46.4
12.	184	184	200	189.3±9.2
13.	364	364	364	364.0±0.0
14*	364	400	428	397.3±32.1
15.	636	636	660	644.0±13.9
16.	400	392	400	397.3±4.6
17.	340	368	344	350.7±15.1
18.	368	368	400	378.7±18.5
19.	344	328	400	357.3±37.8
20*.	328	400	308	345.3±48.4

*Open Dug Wells

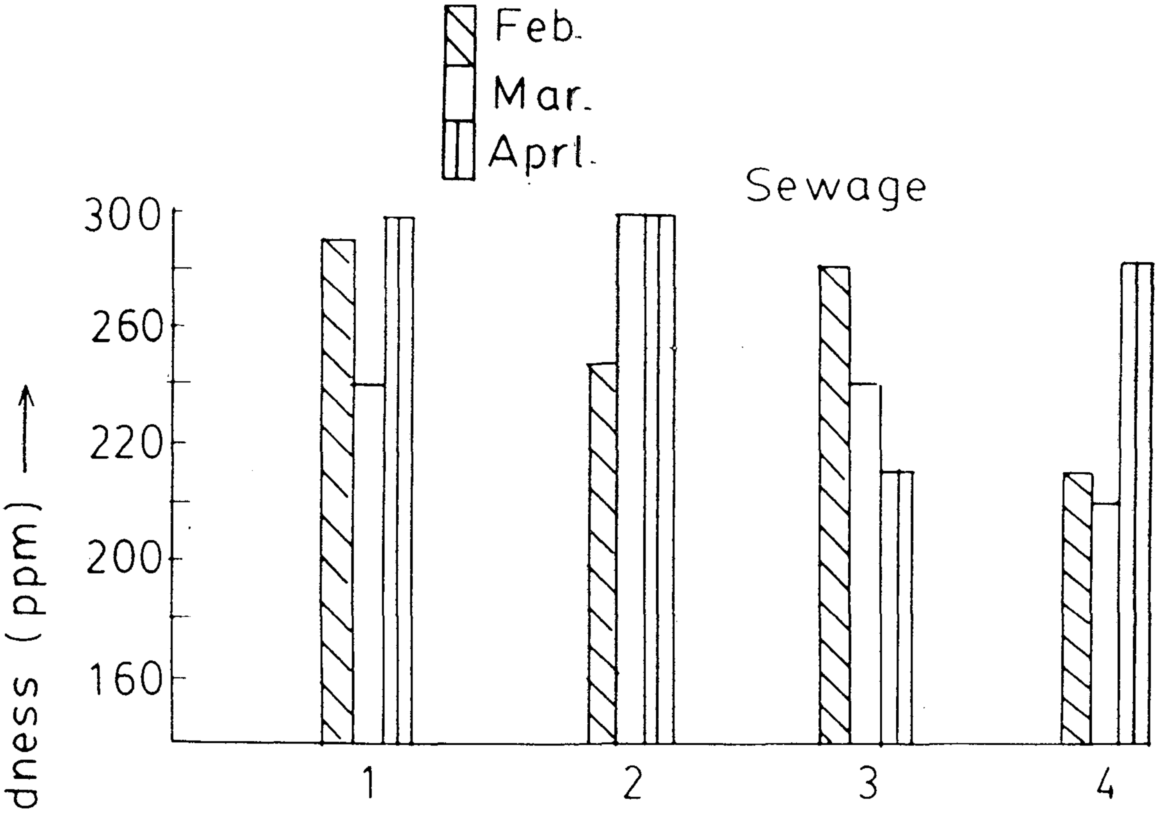


AVERAGE VALUE OF TOTAL HARDNESS IN SAMPLES [ppm]

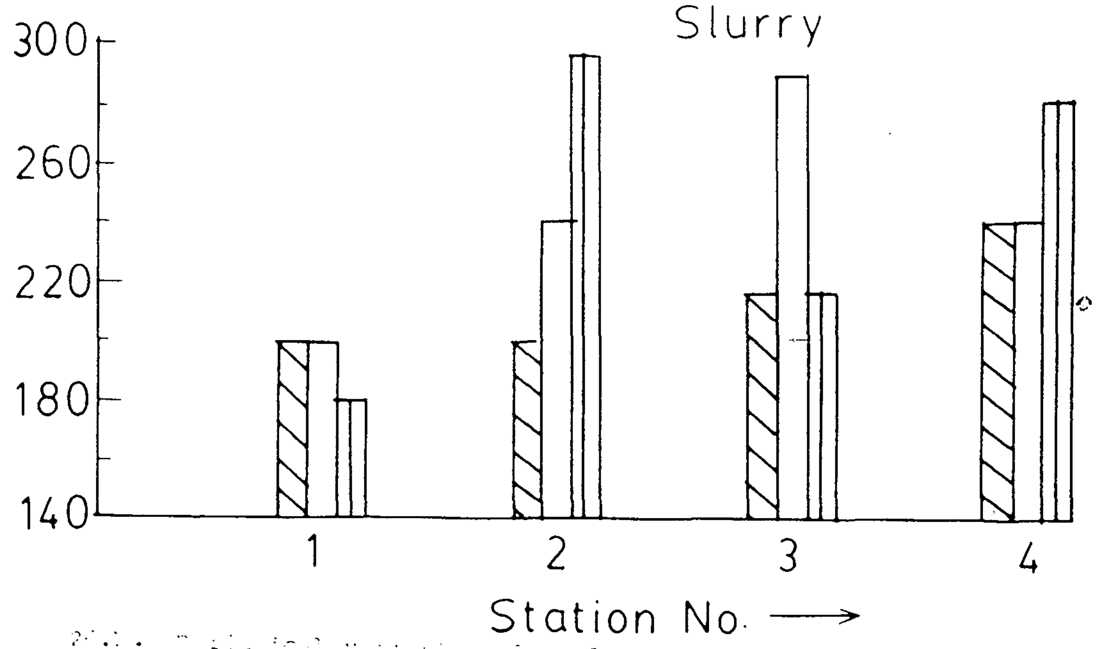
I - Samples of partially treated sewage

II - Samples of slurry water

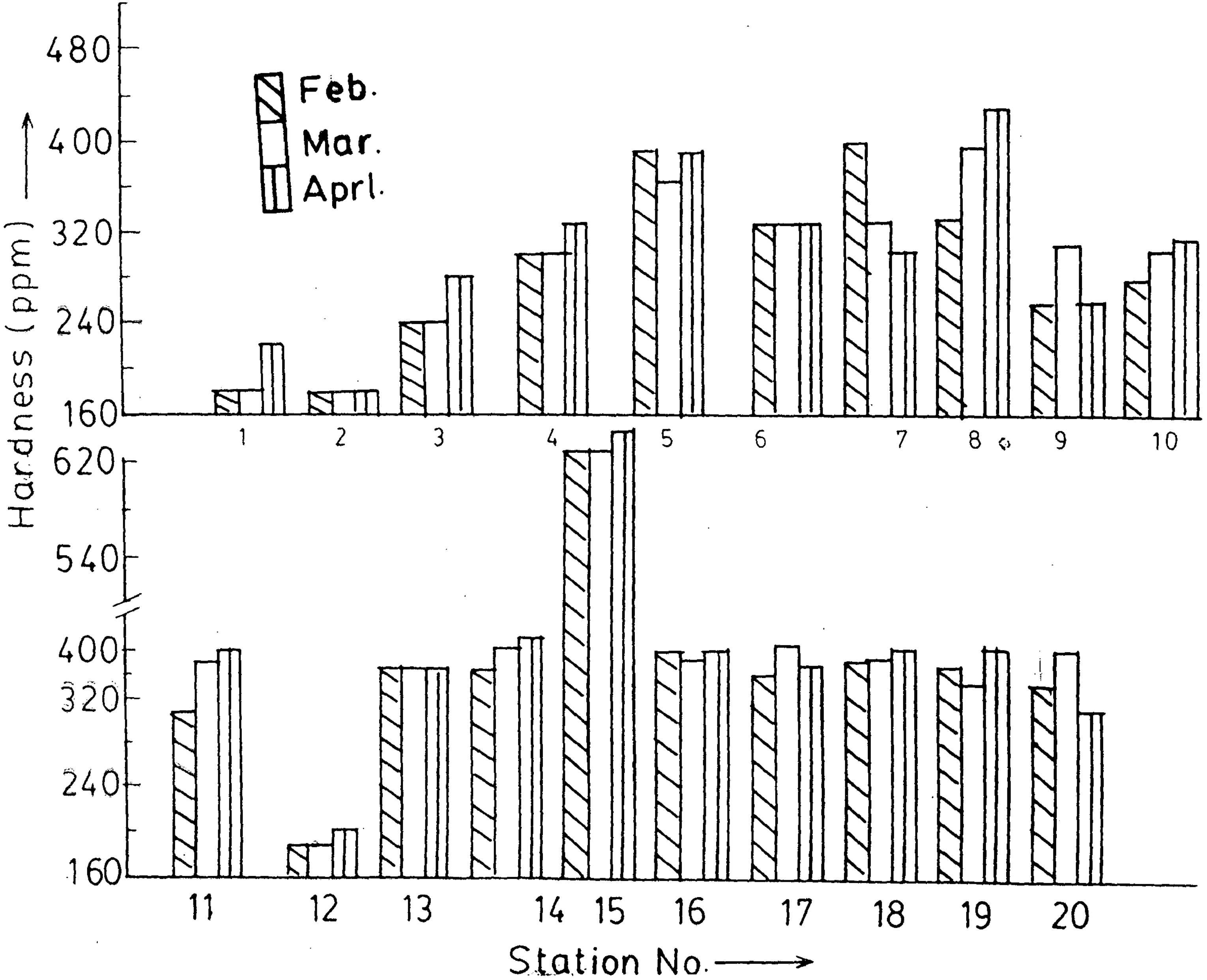
III - Samples of ground water



[illegible] Periodical variation of hardness in partially treated sewage water collected from different stations.



[illegible] Periodical variation of hardness in slurry water collected from different stations.



26.c. Periodical variation of hardness in groundwater collected from different stations.

TDS IN PARTIALLY TREATED SEWAGE WATER AT VARIOUS STATIONS OF FLOW

[In ppm]

Stations	Period Feb	Mar	Apr	Average
1.	399	397.67	385.0	393.9±7.73
2.	357.0	364.0	383.6	368.2±13.8
3.	383.6	406.0	415.0	401.5±16.2
4.	415.0	411.6	364.0	396.9±28.5

TDS IN SLURRY AT VARIOUS POINTS OF ASH POND

[In ppm]

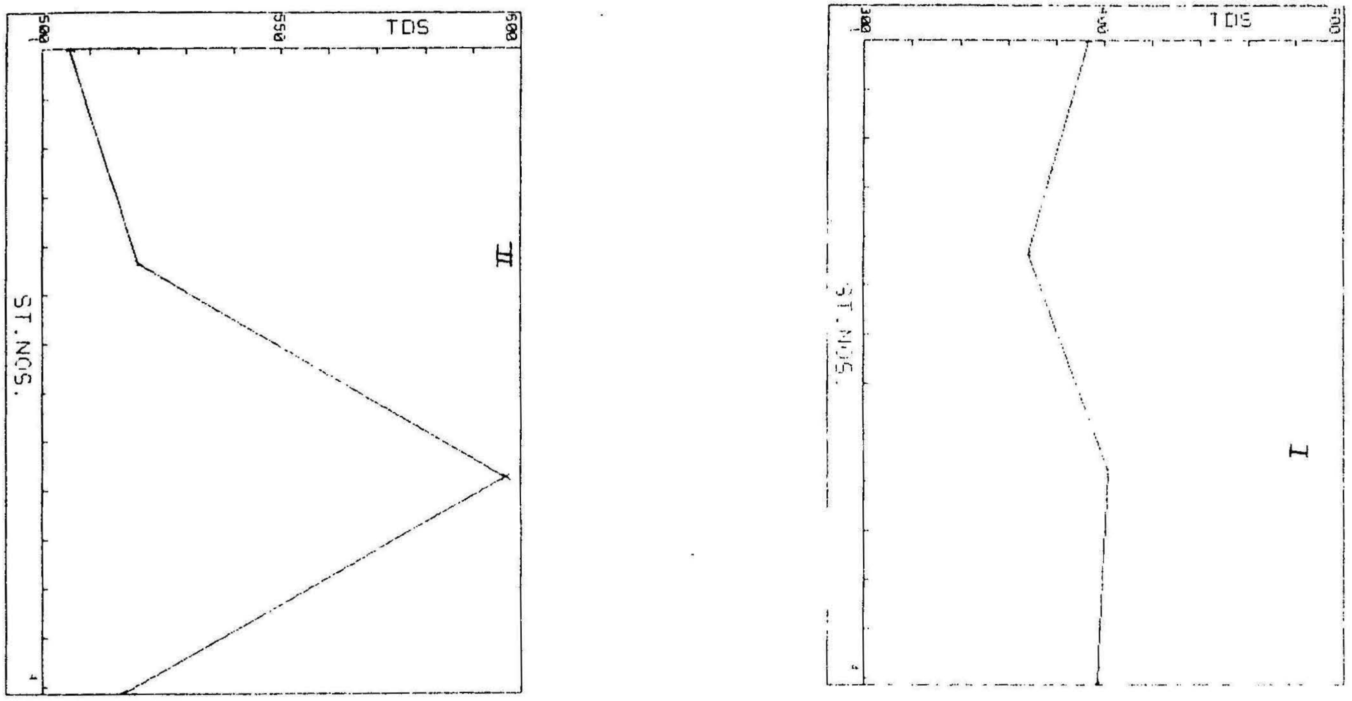
Stations	Period Feb	Mar	Apr	Average
1.	438.2	539.14	539.42	505.6±58.4
2.	539.42	482.02	539.14	520.2±33.1
3.	616.42	552.02	622.02	596.8±38.9
4.	543.37	477.82	529.2	516.7±34.4

TDS OF GROUNDWATER SAMPLES AT VARIOUS STATIONS

[In ppm]

Stations		Period		
	Feb	Mar	Apr	Average
1.	119.42	117.6	105.0	114.0±7.85
2.	122.5	101.71	105.0	109.7±11.2
3.	81.2	84.0	91.0	85.4±5.05
4.	103.94	89.6	105.56	99.7±8.78
5.	90.16	91.0	89.60	90.3±0.70
6.	139.58	126.42	129.78	131.9±6.8
7.	110.6	105.56	88.83	101.7±11.4
8.	87.50	84.0	82.6	84.7±2.52
9.	98.42	85.96	117.6	100.7±15.9
10.	95.48	98.42	105.14	99.7±4.95
11.	81.62	84.42	98.56	88.2±9.1
12.	118.16	118.0	99.82	112.0±10.5
13.	102.55	105.56	111.16	106.4±4.4
14*.	81.62	98.0	117.6	99.1±18.0
15.	126.42	126.42	127.0	126.6±0.3
16.	132.02	109.2	98.42	113.2±17.2
17.	87.92	84.42	104.02	92.1±10.5
18.	123.116	104.02	81.62	102.9±20.8
19.	117.60	117.60	126.0	120.4±4.85
20*.	108.92	98.56	89.6	99.0±9.7

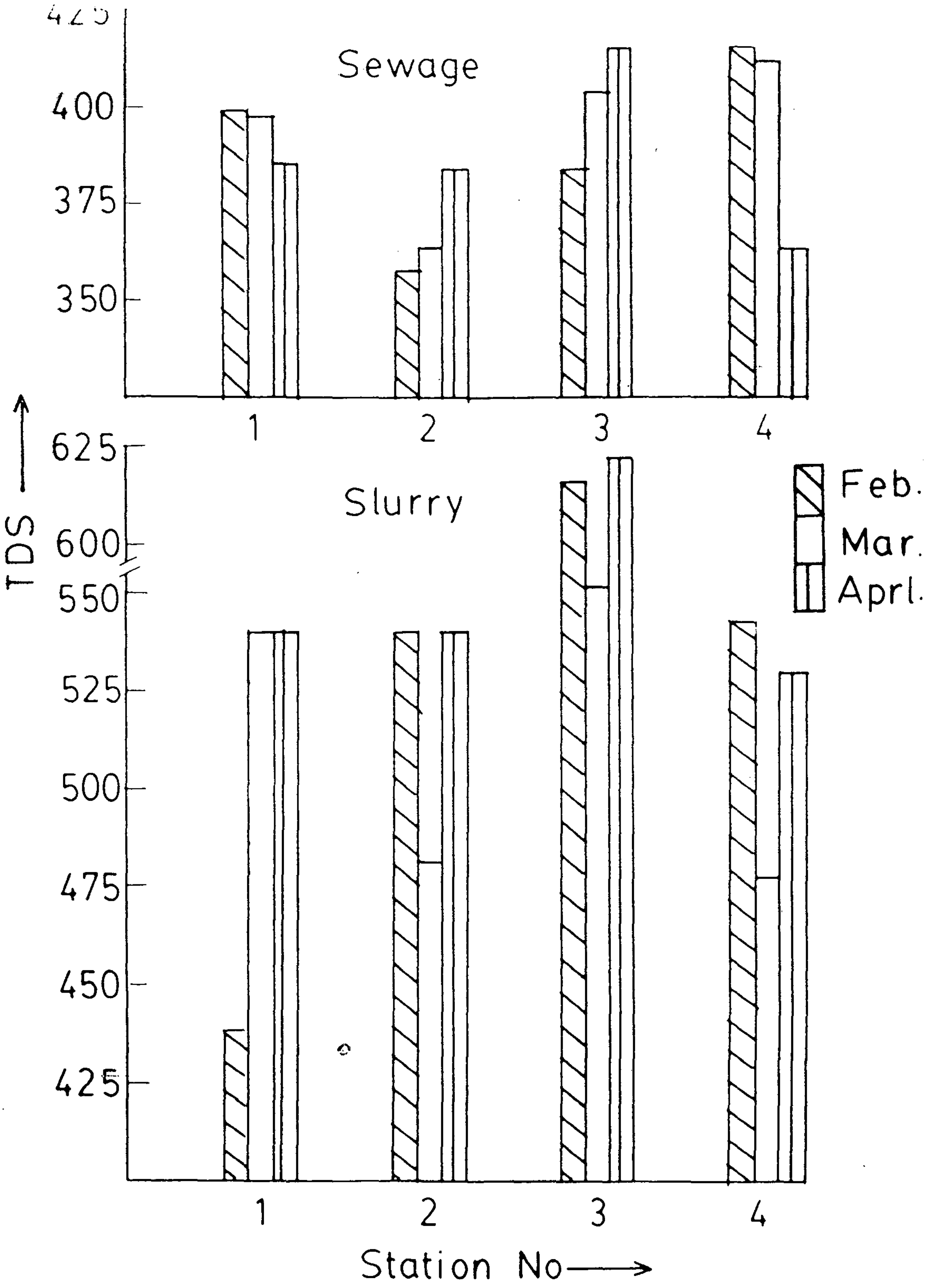
*Open Dug Wells

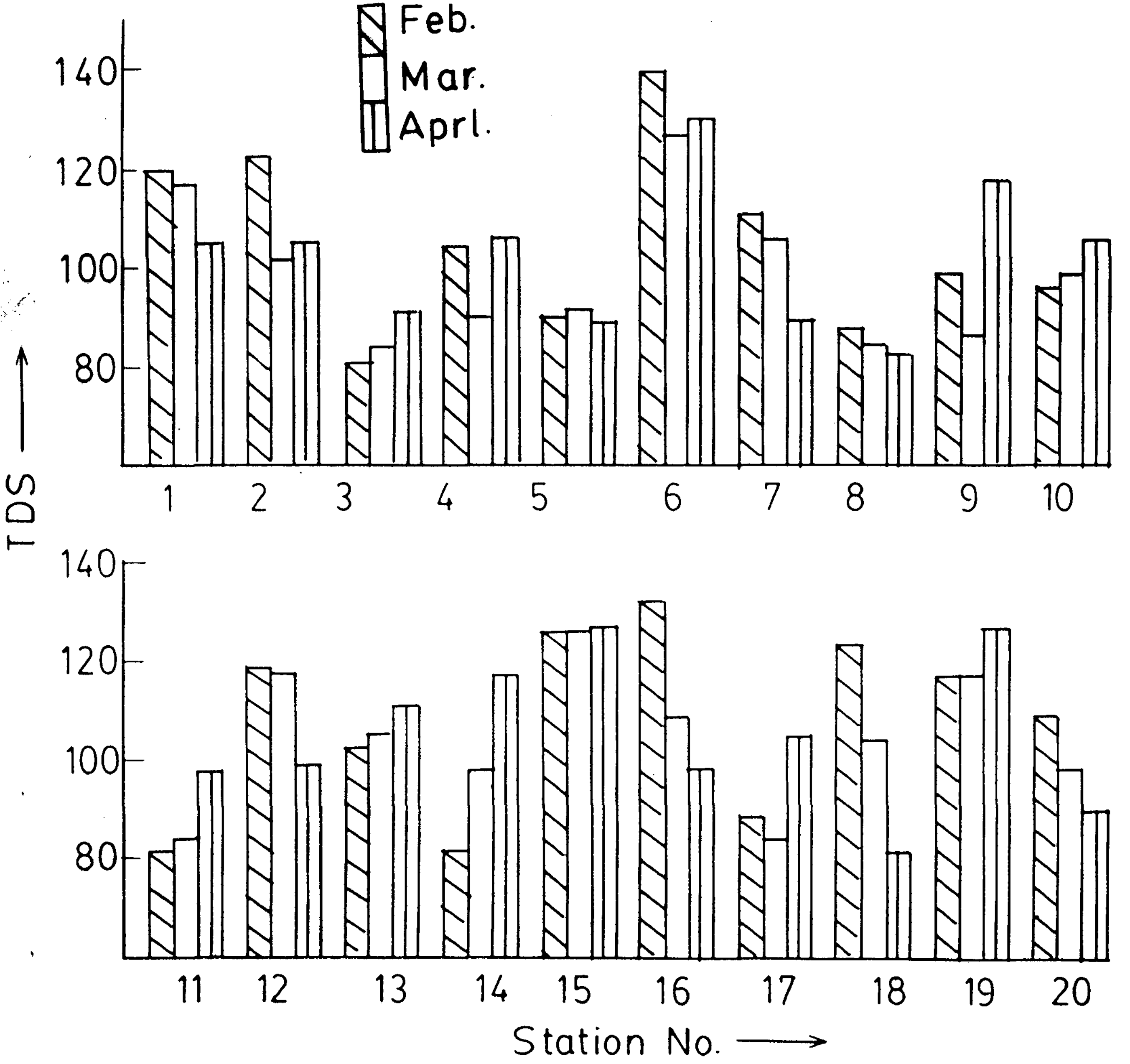


AVERAGE VALUE OF TDS IN SAMPLES [ppm]

I - Samples of partially treated sewage

II - Samples of slurry water


425
Sewage
400
375
350
1
2
3
4
625
Slurry
600
550
525
500
475
450
425
TDS
Feb.
Mar.
Aprl.
1
2
3
4
Station No


Feb.
Mar.
Aprl.
TDS ⟶
140
120
100
80
1
2
3
4
5
6
7
8
9
10
140
120
100
80
11
12
13
14
15
16
17
18
19
20
Station No. ⟶

CHLORIDE CONTENT OF PARTIALLY TREATED SEWAGE FLOW AT DIFFERENT STATIONS

[In ppm]

Stations	Period Feb	Mar	Apr	Average
1.	147.95	169.93	148.18	155.4±12.6
2.	132.0	132.3	126.9	130.4±3.03
3.	79.97	86.62	88.92	85.2±4.6
4.	57.98	58.08	58.12	58.0±0.2

CHLORIDE CONTENT OF SLURRY AT DIFFERENT STATIONS OF THE SLURRY POND

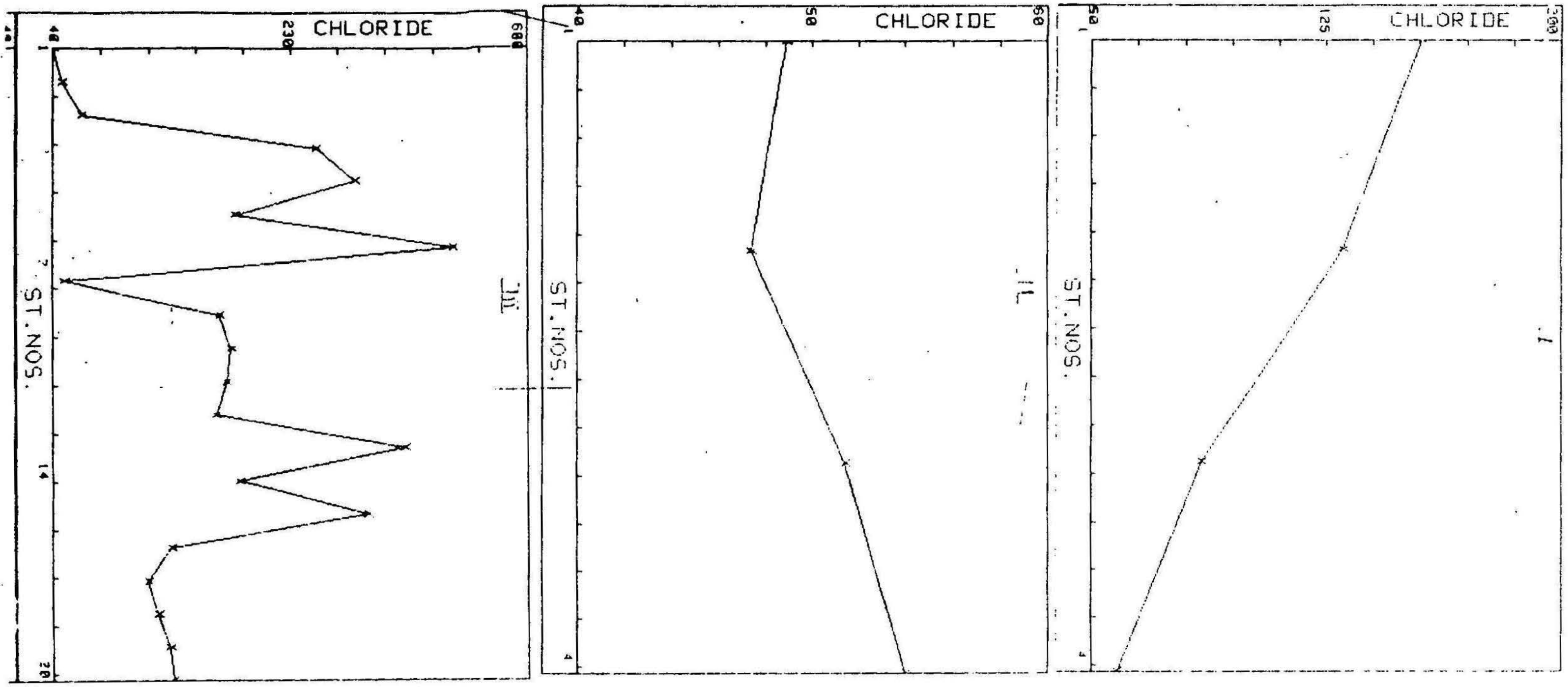
[In ppm]

Stations	Period Feb	Mar	Apr	Average
1.	47.99	50.66	48.17	48.9±1.5
2.	47.99	47.03	47.15	47.4±0.5
3.	49.99	52.19	51.99	51.4±1.2
4.	49.95	56.61	55.55	54.0±3.6

CHLORIDE CONTENT OF GROUND WATER AT VARIOUS STATIONS

[In ppm]

Stations		Period		
	Feb	Mar	Apr	Average
1.	39.99	40.06	40.06	40.0±0.04
2.	49.98	50.83	51.66	50.80±0.8
3.	69.98	72.92	76.87	73.30±3.5
4.	473.90	487.86	490.82	480.70±106.6
5.	403.87	390.60	392.92	395.80±7.1
6.	257.90	243.90	260.87	254.20±9.1
7.	517.80	503.32	518.60	513.20±8.6
8.	46.0	56.03	58.63	53.60±6.7
9.	233.90	240.61	231.19	235.20±4.8
10.	225.90	260.60	260.56	249.0±20.0
11.	223.90	256.71	250.29	243.60±17.3
12.	229.90	230.02	234.14	231.40±2.4
13.	475.90	470.18	418.06	454.70±31.8
14.	257.90	260.21	260.00	259.40±1.30
15.	419.90	400.09	412.60	410.9±10.0
16.	165.90	206.46	160.80	177.70±25.0
17.	146.00	150.20	154.60	150.30±4.3
18.	163.90	168.20	168.20	162.20±7.0
19.	175.90	176.26	176.26	176.10±0.21
20.	175.90	182.60	182.32	180.30±3.8

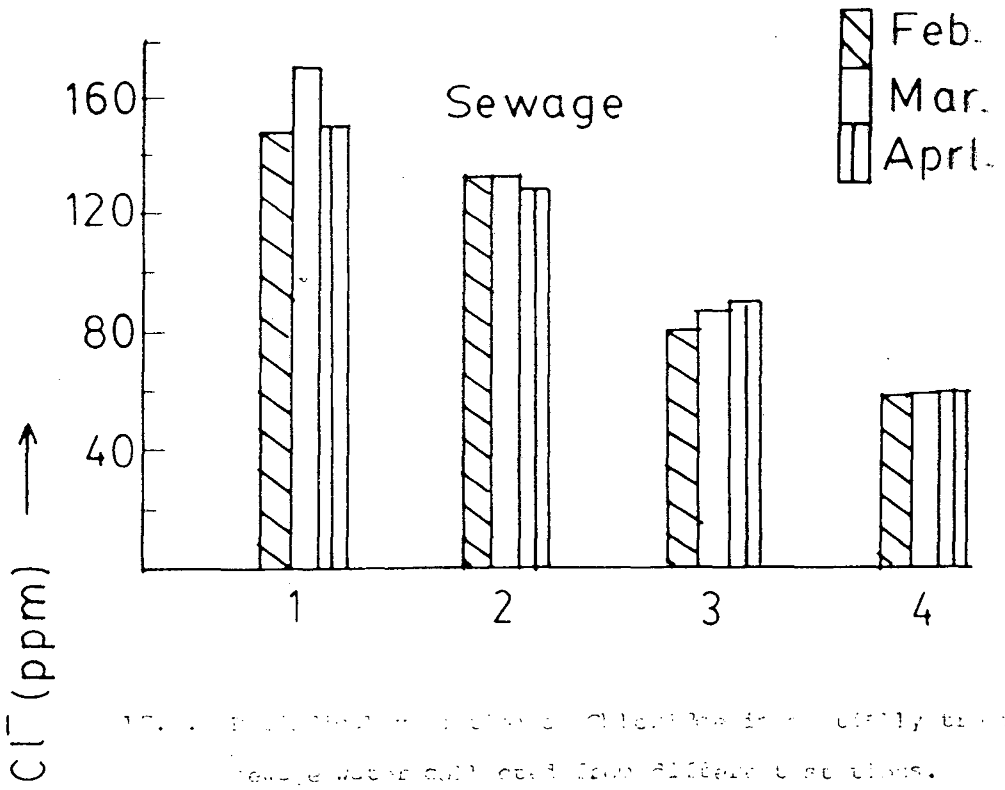


AVERAGE VALUE OF CHLORIDE CONTENT IN SAMPLES [ppm]

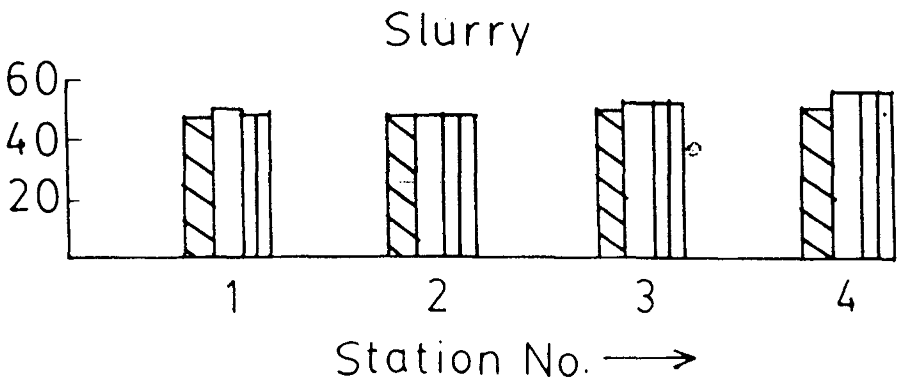
I - Samples of partially treated sewage

II - Samples of slurry water

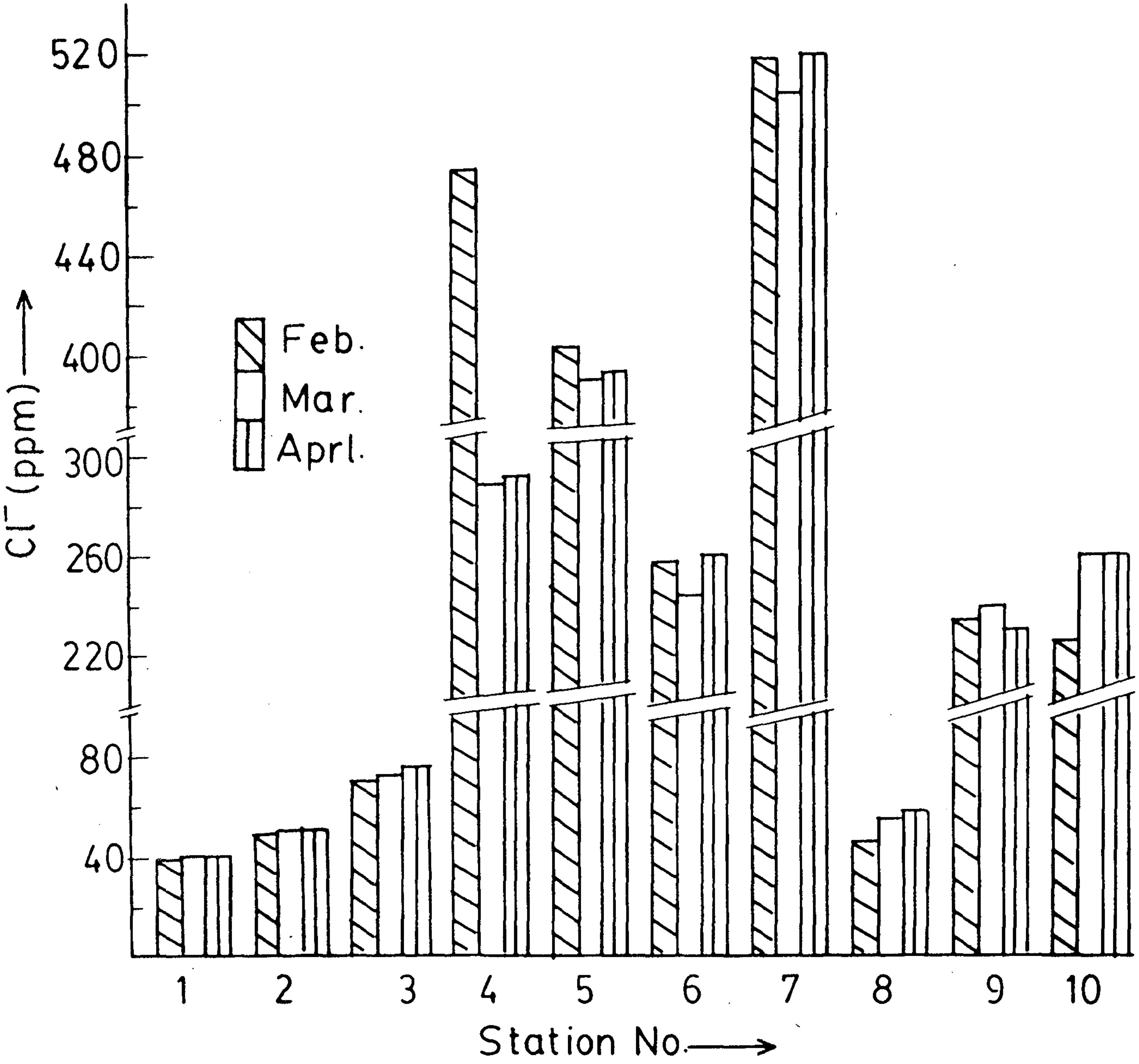
III - Samples of ground water



17.A. Periodical variation of Chloride in partially treated sewage water collected from different stations.



17.B. Periodical variation of Chloride in slurry water collected from different stations.


Cl⁻ (ppm) →
520
480
440
400
300
260
220
80
40
Feb.
Mar.
Aprl.
1
2
3
4
5
6
7
8
9
10
Station No. →

NITRATE AT DIFFERENT POINTS OF PARTIALLY TREATED SEWAGE WATER FLOW

[mg/l]

Stations	Periods			
	Feb	Mar	Apr	Average
1.	8.2	8.6	8.6	8.5±0.23
2.	3.8	4.2	5.9	4.63±1.11
3.	9.4	8.2	13.0	10.2±2.50
4.	6.6	7.4	6.0	6.67±0.70

NITRATE AT DIFFERENT POINTS OF THE SLURRY POND

[mg/l]

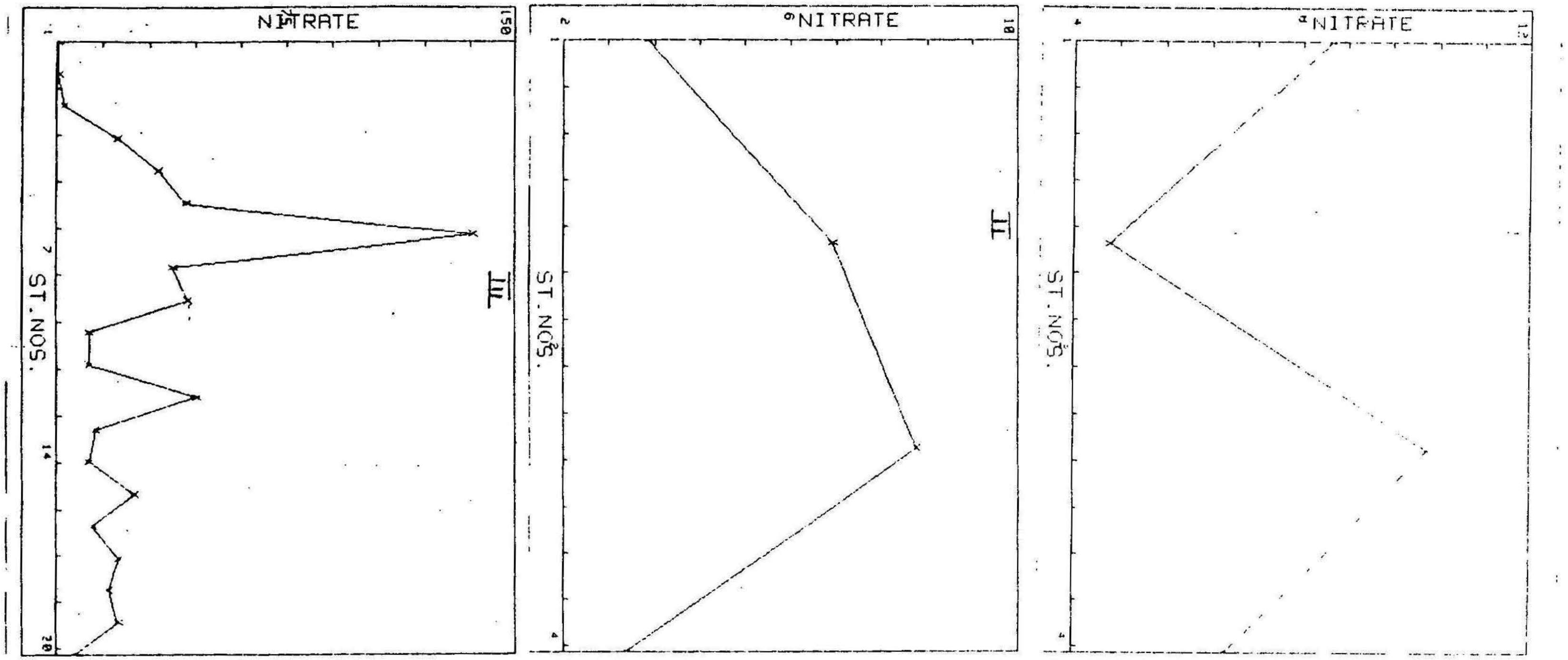
Stations	Periods			
	Feb	Mar	Apr	Average
1.	3.0	3.5	3.9	3.47±0.45
2.	4.6	7.0	8.6	6.73±2.01
3.	7.1	8.6	8.9	8.2±0.96
4.	3.3	3.0	3.0	3.1±0.17

NITRATE AT DIFFERENT STATIONS OF GROUND WATER

[mg/l]

Stations	Period Feb	 Mar	 Apr	Average
1.	1.3	0.96	1.7	1.32±0.37
2.	1.9	1.70	1.82	1.47±0.50
3.	3.0	3.5	3.3	3.27±0.25
4.	19.3	20.6	21.9	20.6±1.3
5.	27.7	34.5	39.2	33.8±5.79
6.	41.3	40.0	46.6	42.6±3.5
7.	182.4	109.2	116.4	136.0±40.3
8.	34.4	38.6	42.3	38.4±3.9
9.	42.3	39.9	47.6	43.3±3.9
10.	13.4	10.4	10.6	11.5±1.7
11.	12.0	9.3	13.6	11.6±2.2
12.	42.1	48.5	47.3	46.0±3.4
13.	19.6	18.4	12.6	13.5±5.6
14*.	12.0	10.7	11.9	11.5±0.72
15.	29.2	28.6	20.3	26.0±5.0
16.	15.3	17.9	12.6	12.6±3.7
17.	23.2	18.9	20.7	20.9±2.2
18.	19.5	16.6	24.9	20.25±4.2
19.	14.6	18.8	19.0	16.61±2.12
20*.	8.3	9.0	7.2	8.3±2.4

*Open Dug Wells



AVERAGE VALUE OF NITRATE CONTENT IN SAMPLES [ppm]

I - Samples of partially treated sewage
II - Samples of slurry water
III - Samples of ground water

NITRITE AT DIFFERENT POINTS OF PARTIALLY TREATED SEWAGE WATER FLOW

[mg/l]

Stations		Periods		
	Feb	Mar	Apr	Average
1.	18.2	15.22	19.61	11.0±6.6
2.	5.33	6.72	6.21	6.42±0.3
3.	13.36	18.76	14.22	15.78±5.4
4.	0.30	0.82	0.65	1.26±1.23

NITRITE AT DIFFERENT POINTS OF THE SLURRY POND

[mg/l]

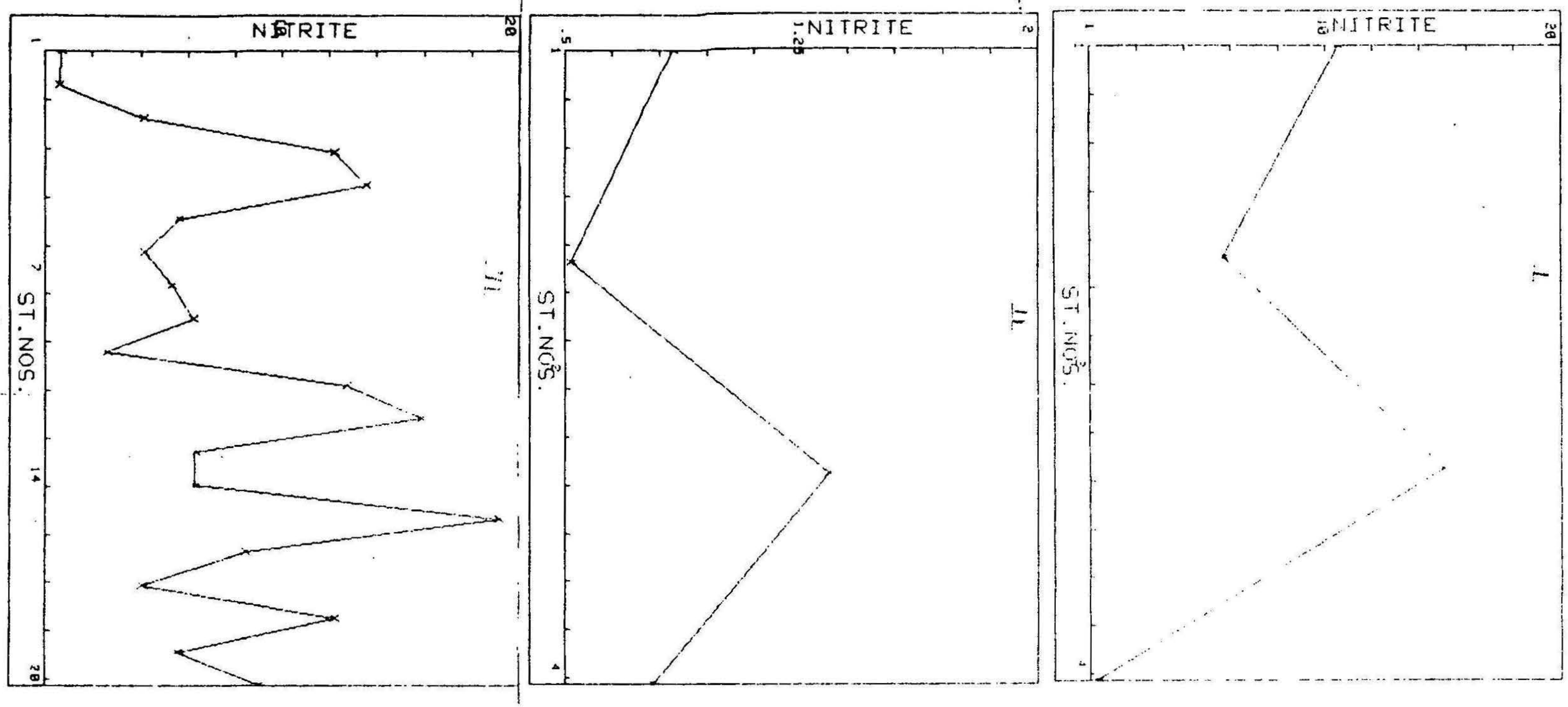
Stations		Period		
	Feb	Mar	Apr	Average
1.	0.72	1.12	0.68	0.84±0.24
2.	0.22	0.47	0.86	0.52±0.32
3.	2.61	0.56	0.86	1.34±1.11
4.	0.35	0.83	1.18	1.79±2.1

NITRITE AT DIFFERENT STATIONS OF GROUND WATER

[mg/l]

Stations	Period Feb	Mar	Apr	Average
1.	1.22	2.06	1.61	1.63±0.42
2.	3.71	2.23	2.67	1.54±1.9
3.	2.81	3.06	8.83	4.9±3.4
4.	15.67	18.22	13.91	12.6±6.4
5.	18.92	12.62	10.26	13.9±4.5
6.	8.86	6.92	8.25	6.34±2.8
7.	5.03	5.12	6.73	4.96±1.80
8.	3.19	4.26	4.76	3.9±0.3
9.	8.82	9.71	10.26	6.93±4.1
10.	2.86	3.72	3.82	3.47±0.53
11.	14.82	15.62	18.82	13.1±3.7
12.	15.62	14.89	17.92	16.1±1.6
13.	8.80	8.72	8.52	7.0±2.9
14*	8.672	10.06	10.12	7.0±5.4
15.	21.65	18.06	18.0	19.2±2.1
16.	8.72	9.22	9.0	9.0±0.3
17.	5.62	4.86	4.16	4.88±0.73
18.	14.82	18.0	15.03	12.6±6.8
19.	5.22	8.72	9.82	6.3±2.1
20*.	9.22	11.62	7.84	9.6±1.9

*Open Dug Wells



AVERAGE VALUE OF NITRITE CONTENT IN SAMPLES [ppm]

I - Samples of partially treated sewage

II - Samples of slurry water

III - Samples of ground water

PHOSPHATE AT DIFFERENT STATIONS OF PARTIALLY TREATED SEWAGE FLOW

[In ppm]

Stations		Period		
	Feb	Mar	Apr	Average
1.	4.68	5.92	4.86	5.12±0.6
2.	3.96	4.90	5.65	4.84±0.84
3.	4.58	4.89	4.46	4.65±0.22
4.	1.38	1.40	1.59	1.46±0.11

PHOSPHATE AT DIFFERENT POINTS OF SLURRY POND

[In ppm]

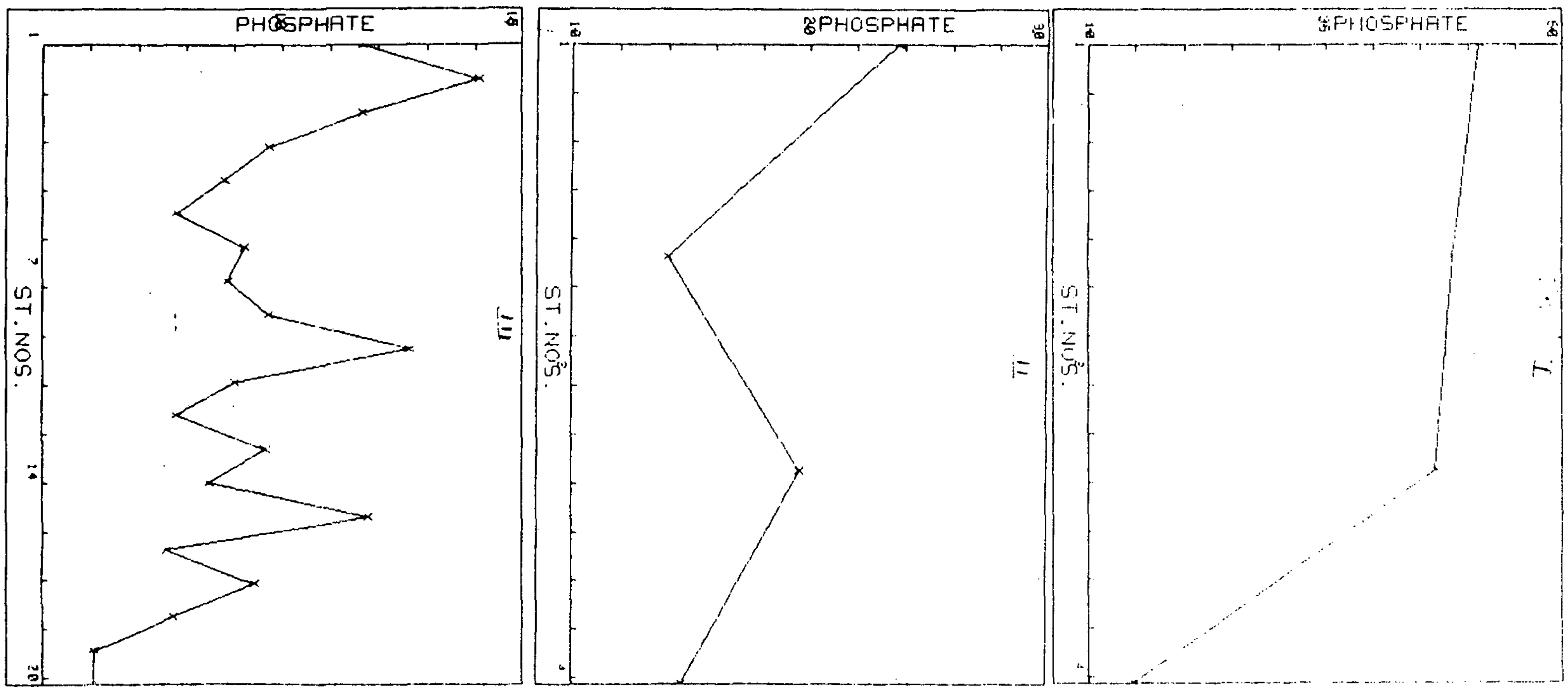
Stations		Period		
	Feb	Mar	Apr	Average
1.	1.99	2.28	2.84	2.37±0.43
2.	1.00	1.89	1.30	1.40±0.45
3.	1.53	2.08	2.27	1.96±0.38
4.	1.38	1.40	1.59	1.46±0.11

PHOSPHATE OF GROUNDWATER FROM DIFFERENT STATIONS

[In ppm]

Stations	Period Feb	 Mar	 Apr	Average
1.	1.04	0.90	1.12	1.03±0.11
2.	1.03	1.20	1.86	1.37±0.44
3.	0.91	1.00	1.18	1.03±0.14
4.	0.62	0.98	0.67	0.76±0.20
5.	0.79	0.59	0.49	0.63±0.15
6.	0.55	0.50	0.42	0.49±0.07
7.	0.61	0.71	0.72	0.69±0.06
8.	0.63	0.62	0.66	0.64±0.02
9.	0.57	0.83	0.87	0.76±0.16
10.	1.10	1.20	1.20	1.17±0.06
11	0.58	0.68	0.71	0.66±0.07
12.	0.27	0.38	0.81	0.49±0.29
13.	0.43	0.60	1.20	0.75±0.40
14*	0.55	0.61	0.58	0.58±0.03
15.	0.80	0.99	1.36	1.05±0.28
16.	0.36	0.50	0.52	0.46±0.09
17.	0.42	0.87	0.86	0.72±0.25
18.	0.49	0.38	0.57	0.48±0.09
19.	0.16	0.29	0.28	0.25±0.07
20*.	0.12	0.30	0.31	0.25±0.11

*Open Dug Wells



AVERAGE VALUE OF PHOSPHATE CONTENT IN SAMPLES [ppm]

I - Samples of partially treated sewage

II - Samples of slurry water

III - Samples of ground water

SULPHATE CONTENT OF PARTIALLY TREATED SEWAGE FLOW AT DIFFERENT STATIONS

[mg/l]

Stations	Period Feb	Mar	Apr	Average
1.	82.5	106.60	101.92	97.0±12.8
2.	129.9	134.60	139.09	134.5±4.6
3.	53.3	56.00	58.03	55.8±2.4
4.	56.0	64.00	68.66	62.9±6.4

SULPHATE CONTENT OF SLURRY AT DIFFERENT STATIONS OF SLURRY POND

[mg/l]

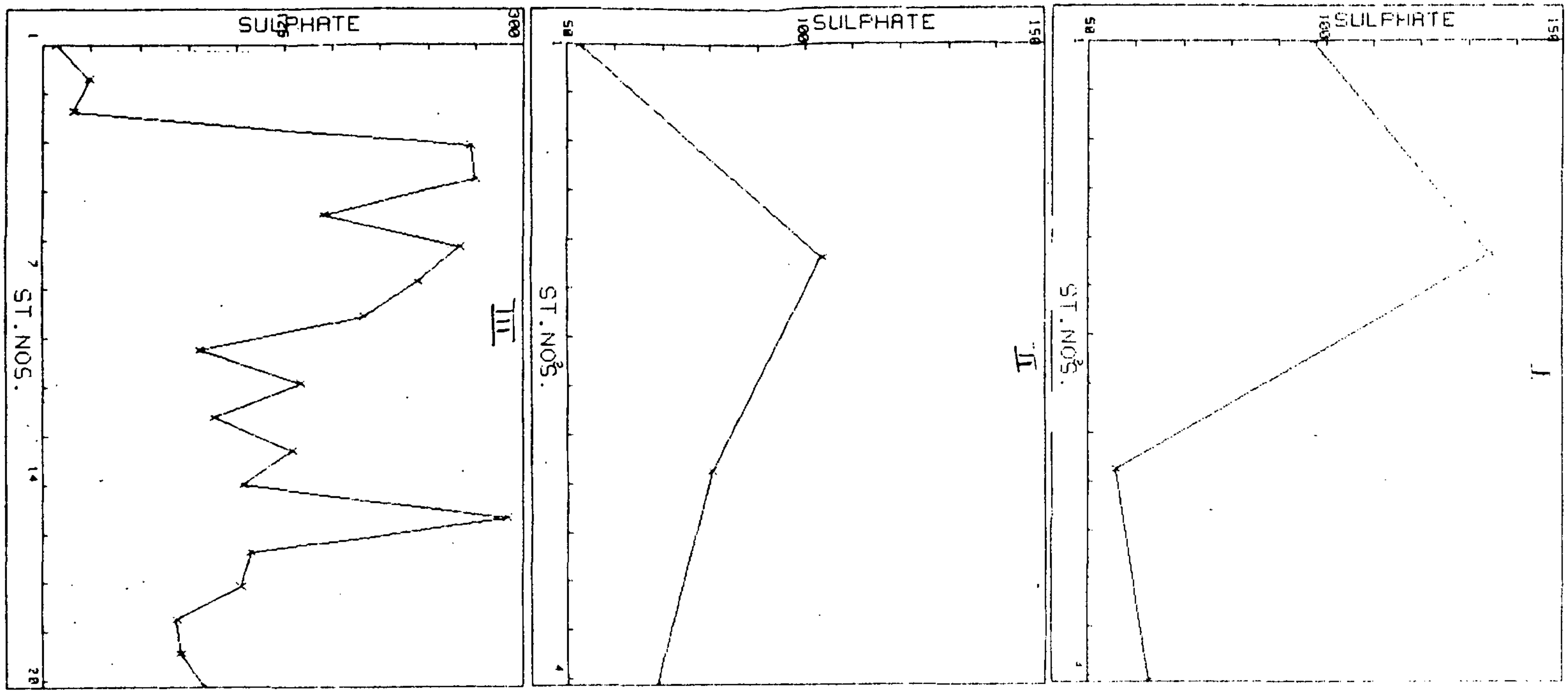
Stations	Period Feb	Mar	Apr	Average
1.	54.5	50.82	52.06	52.5±1.9
2.	80.4	114.49	115.20	103.4±19.9
3.	80.4	80.20	80.32	80.3±0.10
4.	58.1	68.32	79.83	68.8±10.9

SULPHATE CONTENTS OF GROUNDWATER OF DIFFERENT STATIONS

[In ppm]

Stations		Period		
	Feb	Mar	Apr	Average
1.	94.3	99.36	92.59	95.4±3.5
2.	107.2	112.60	121.86	109.9±3.8
3.	99.3	98.62	111.83	103.3±7.4
4.	281.6	272.30	276.32	276.7±4.7
5.	256.3	293.52	286.60	278.8±19.8
6.	198.9	216.82	219.68	211.8±11.3
7.	248.9	286.34	280.32	271.8±20.1
8.	239.5	258.60	262.48	253.5±12.3
9.	180.6	168.42	191.81	190.6±56.7
10.	156.1	148.62	168.39	157.7±10.0
11.	188.5	206.43	210.30	201.7±11.4
12.	151.7	172.09	168.32	164.0±10.8
13.	200.42	196.99	196.63	198.0±2.1
14*	168.2	179.39	182.33	176.6±7.5
15.	295.8	299.60	283.24	292.9±8.4
16.	175.0	179.93	186.29	180.4±5.7
17.	175.0	176.36	176.25	175.9±0.8
18.	131.1	148.90	162.50	147.5±15.7
19.	152.3	148.20	148.20	149.6±2.4
20*.	149.7	160.20	169.92	159.9±10.1

*Open Dug Wells



AVERAGE VALUE OF SULPHATE CONTENT IN SAMPLES [ppm]

I - Samples of partially treated sewage

II - Samples of slurry water

III - Samples of ground water

SILICA CONTENT OF PARTIALLY TREATED SEWAGE FLOW AT DIFFERENT STATIONS

[In ppm]

Stations	Period Feb	Mar	Apr	Average
1.	6.44	6.58	6.52	6.5±0.1
2.	8.04	8.78	8.12	8.3±0.4
3.	8.98	8.72	8.92	8.9±0.1
4.	4.07	4.12	4.28	4.2±0.1

SILICA CONTENT OF SLURRY AT DIFFERENT STATIONS OF THE ASH POND

[In ppm]

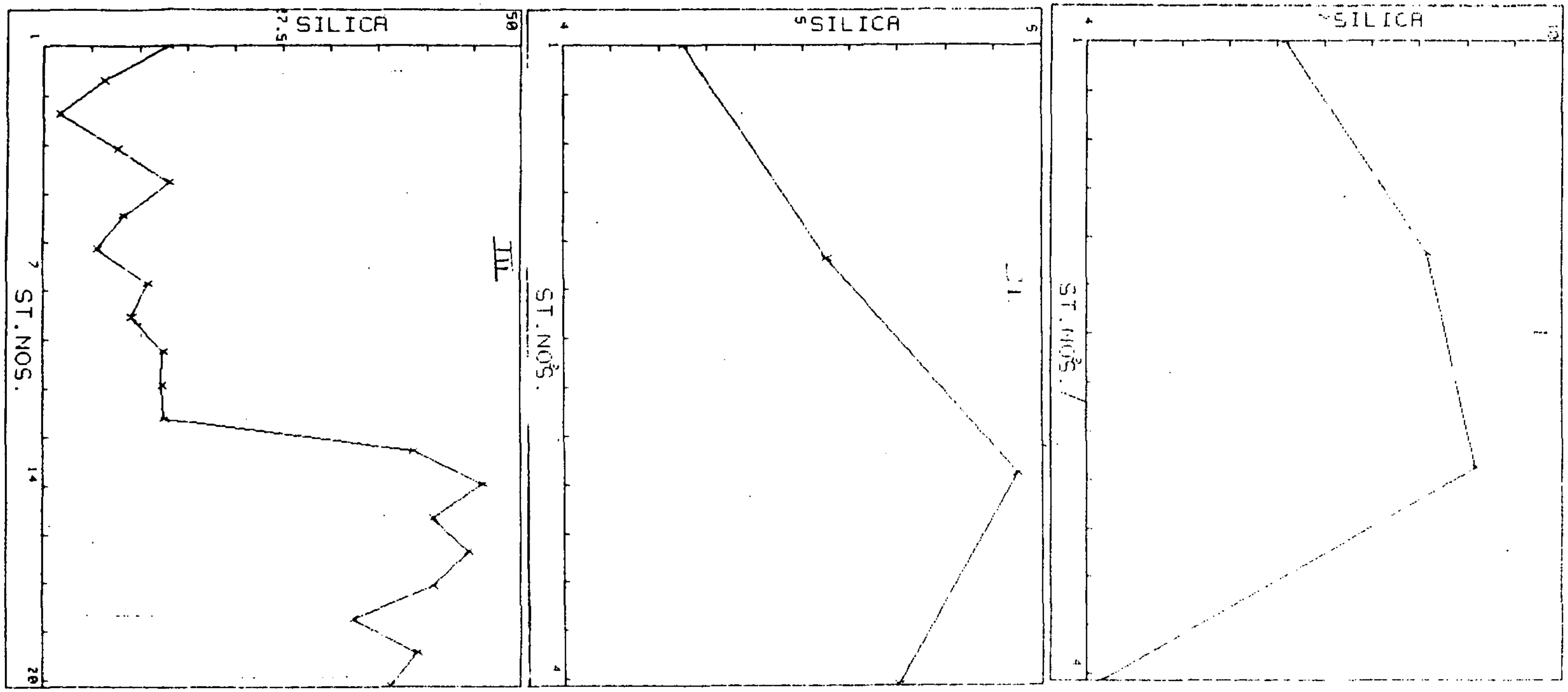
Stations	Period Feb	Mar	Apr	Average
1.	4.18	4.96	4.27	4.5±0.4
2.	5.17	5.29	4.86	5.1±0.2
3.	5.89	5.88	5.86	5.9±0.1
4.	5.12	5.66	5.29	5.4±0.3

SILICA CONTENT OF GROUNDWATER AT DIFFERENT STATIONS

[In ppm]

Stations	Period Feb	 Mar	 Apr	 Average
1.	16.32	17.02	16.63	16.7±0.4
2.	10.53	10.66	10.48	10.6±0.1
3.	6.44	6.58	6.52	6.5±0.1
4.	11.47	11.30	12.92	11.9±0.9
5.	13.62	18.62	18.22	16.8±2.8
6.	12.46	12.06	12.62	12.4±0.3
7.	10.58	9.64	9.68	10.0±0.5
8.	14.28	14.96	14.86	14.7±0.4
9.	13.23	13.25	13.25	13.2±0.01
10.	13.56	17.06	17.84	16.2±2.3
11.	14.01	17.06	17.25	16.1±1.8
12.	15.59	16.60	16.62	16.3±0.6
13.	38.51	40.66	40.33	39.8±1.2
14*	41.77	48.76	48.22	46.3±3.9
15.	42.32	40.86	41.63	41.6±0.7
16.	42.38	48.61	43.92	45.0±3.2
17.	39.73	42.21	42.73	41.6±1.6
18.	33.88	34.52	34.28	34.1±0.6
19.	39.31	40.04	40.86	40.1±0.8
20*.	39.29	36.60	36.82	37.6±1.5

*Open Dug Wells



AVERAGE VALUE OF SILICA CONTENT IN SAMPLES [ppm]

I - Samples of partially treated sewage

II - Samples of slurry water

III - Samples of ground water

FLUORIDE CONTENT OF PARTIALLY TREATED SEWAGE FLOW AT DIFFERENT STATIONS

[In ppm]

Stations	Period Feb	Mar	Apr	Average
1.	0.494	0.493	0.493	0.493±0.001
2.	0.683	0.660	0.691	0.678±0.02
3.	0.633	0.618	0.621	0.624±0.01
4.	3.650	3.550	3.560	3.59±0.06

FLUORIDE CONTENT OF SLURRY AT DIFFERENT STATIONS OF THE ASH POND

[In ppm]

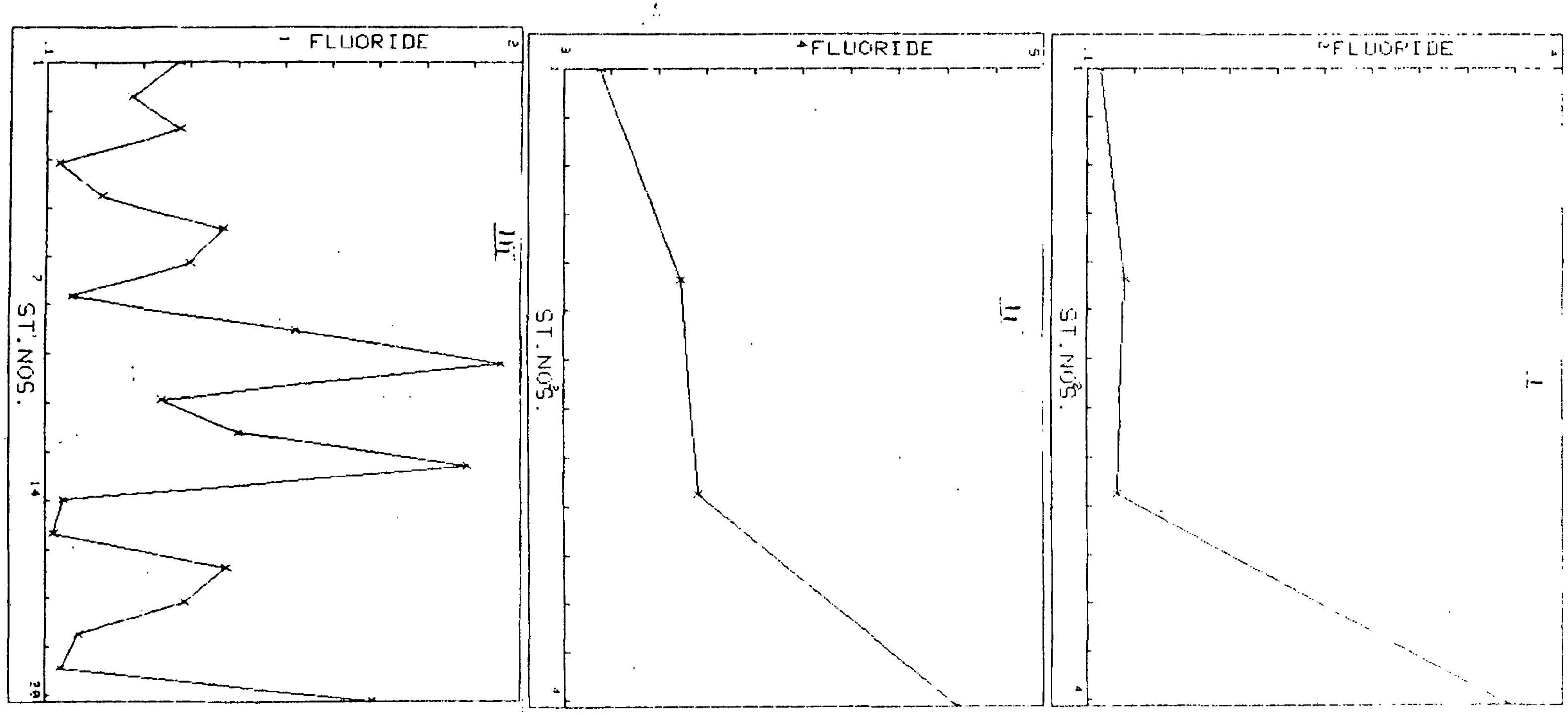
Stations	Period Feb	Mar	Apr	Average
1.	3.24	3.08	3.13	3.15±0.1
2.	3.37	3.18	3.91	3.49±0.4
3.	3.50	3.68	3.51	3.56±0.10
4.	4.15	5.09	4.68	4.64±0.5

FLUORIDE CONTENT OF GROUNDWATER AT DIFFERENT STATIONS

[In ppm]

Stations	Period Feb	Mar	Apr	Average
1.	0.530	0.618	0.617	0.588±0.05
2.	0.442	0.486	0.418	0.449±0.03
3.	0.591	0.586	0.591	0.59±0.01
4.	0.235	0.238	0.235	0.236±0.01
5.	0.354	0.358	0.373	0.362±0.01
6.	0.707	0.719	0.725	0.717±0.01
7.	0.622	0.612	0.619	0.618±0.01
8.	0.250	0.265	0.306	0.274±0.03
9.	0.982	0.907	0.913	0.934±0.04
10.	1.500	1.620	1.510	1.54±0.07
11.	0.525	0.568	0.521	0.538±0.03
12.	0.700	0.763	0.829	0.764±0.06
13.	1.420	1.480	1.430	1.44±0.03
14*.	0.247	0.258	0.250	0.252±0.06
15.	0.226	0.225	0.217	0.223±0.05
16.	0.755	0.707	0.717	0.726±0.03
17.	0.588	0.619	0.606	0.604±0.02
18.	0.210	0.292	0.388	0.297±0.09
19.	0.234	0.234	0.268	0.245±0.02
20*.	1.160	1.210	1.120	1.16±0.05

*Open Dug Wells



AVERAGE VALUE OF FLUORIDE CONTENT IN SAMPLES [ppm]

I - Samples of partially treated sewage

II - Samples of slurry water

III - Samples of ground water

POTASSIUM CONTENT OF THE PARTIALLY TREATED SEWAGE AT DIFFERENT STATIONS

[In ppm]

Stations	Period Feb	Mar	Apr	Average
1.	48.4	45.56	45.13	46.4±1.8
2.	49.6	50.08	50.17	50.0±0.3
3.	18.9	20.21	21.73	20.3±1.40
4.	20.0	22.18	22.92	21.7±1.5

POTASSIUM CONTENT OF THE SLURRY AT VARIOUS POINTS OF THE ASH POND

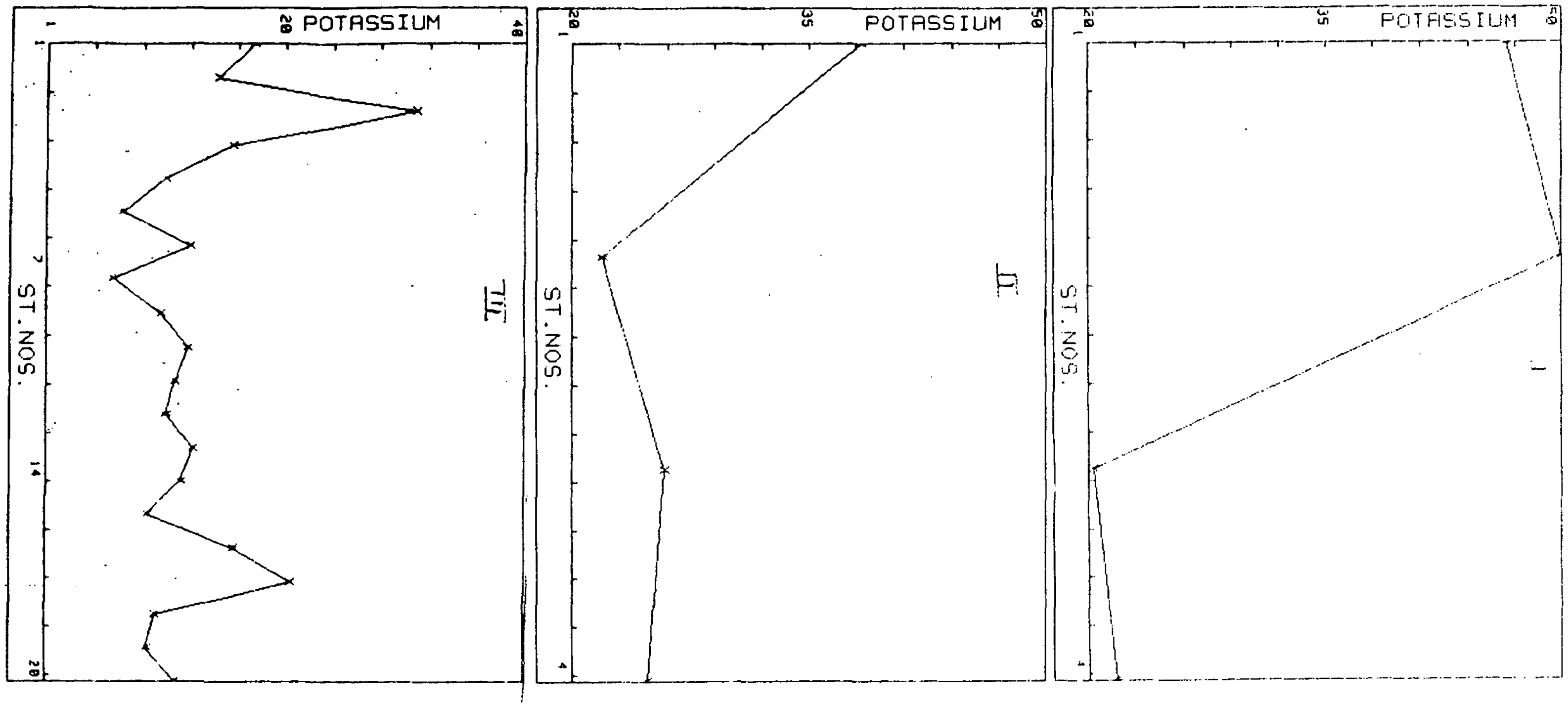
[In ppm]

Stations	Period Feb	Mar	Apr	Average
1.	37.5	37.62	39.92	38.3±1.4
2.	21.7	21.00	22.86	21.9±0.9
3.	22.6	26.81	28.08	25.8±2.9
4.	21.6	22.82	29.71	24.7±4.4

POTASSIUM CONTENT OF GROUND WATER AT VARIOUS SAMPLING STATIONS

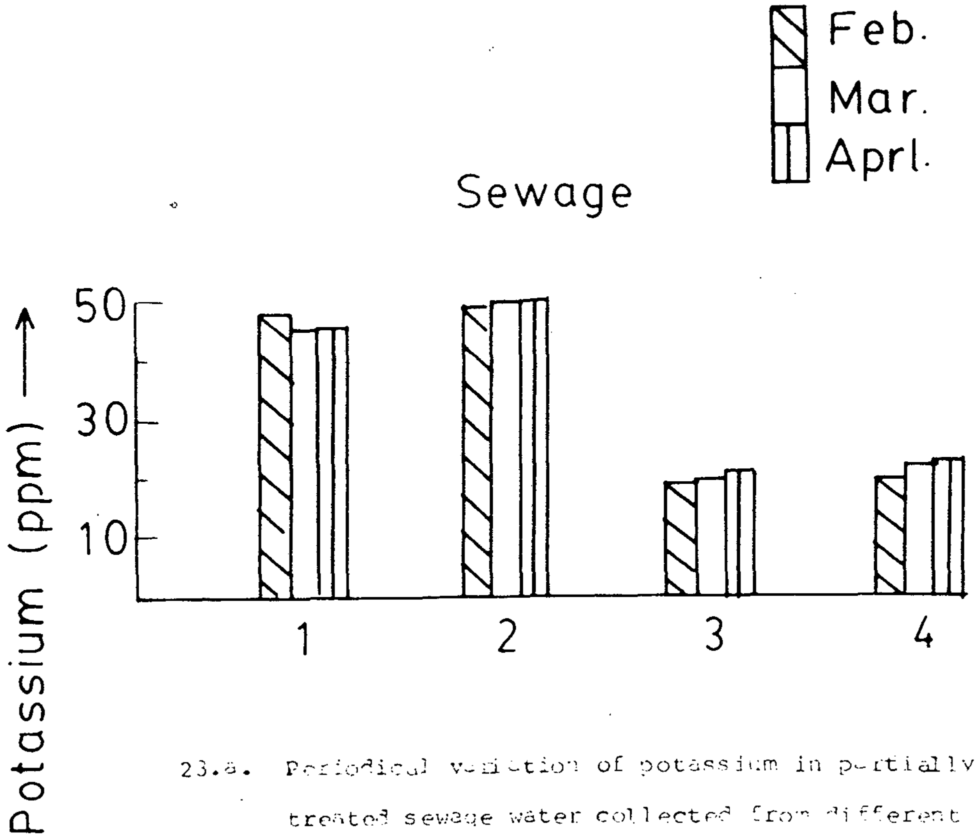
[In ppm]

Stations	Period Feb	 Mar	 Apr	 Average
1.	18.3	17.21	18.29	17.90±0.62
2.	12.4	13.92	18.70	15.0±3.3
3.	30.9	30.12	32.16	31.10±1.0
4.	14.8	16.81	16.82	16.10±1.2
5.	10.5	10.5	10.84	10.60±0.2
6.	6.74	7.06	7.82	7.21±0.6
7.	10.8	13.66	13.62	12.70±1.6
8.	6.52	6.56	6.18	6.42±0.2
9.	9.71	10.81	10.29	10.20±0.6
10.	12.2	12.60	12.60	12.50±0.2
11.	11.6	11.22	11.33	11.40±0.2
12.	10.6	10.51	10.96	10.70±0.2
13.	12.90	12.96	12.92	12.90±0.03
14.	10.00	12.66	13.11	11.90±1.7
15.	8.50	9.56	9.62	9.20±.6
16.	15.5	16.62	16.62	16.20±0.6
17.	19.4	21.64	21.58	20.90±1.3
18.	9.75	9.72	10.09	9.90±0.2
19.	9.00	9.02	9.61	9.20±0.3
20.	11.90	11.29	11.35	11.50±0.3

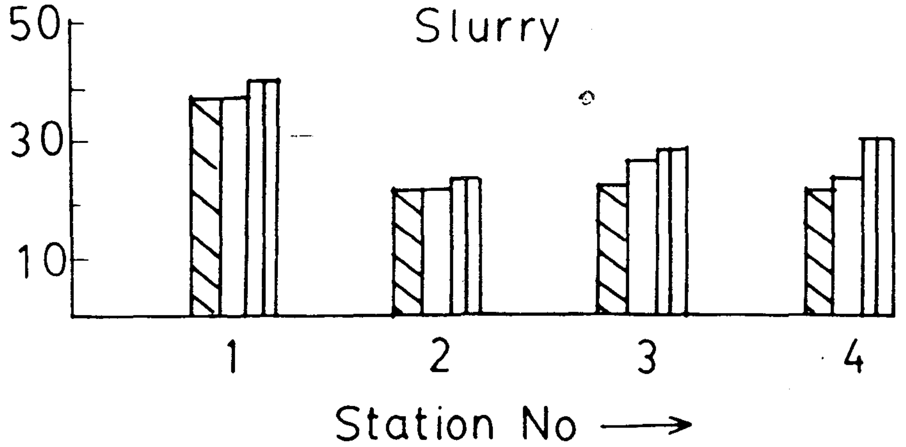


AVERAGE VALUE OF POTASSIUM CONTENT IN SAMPLES [ppm]

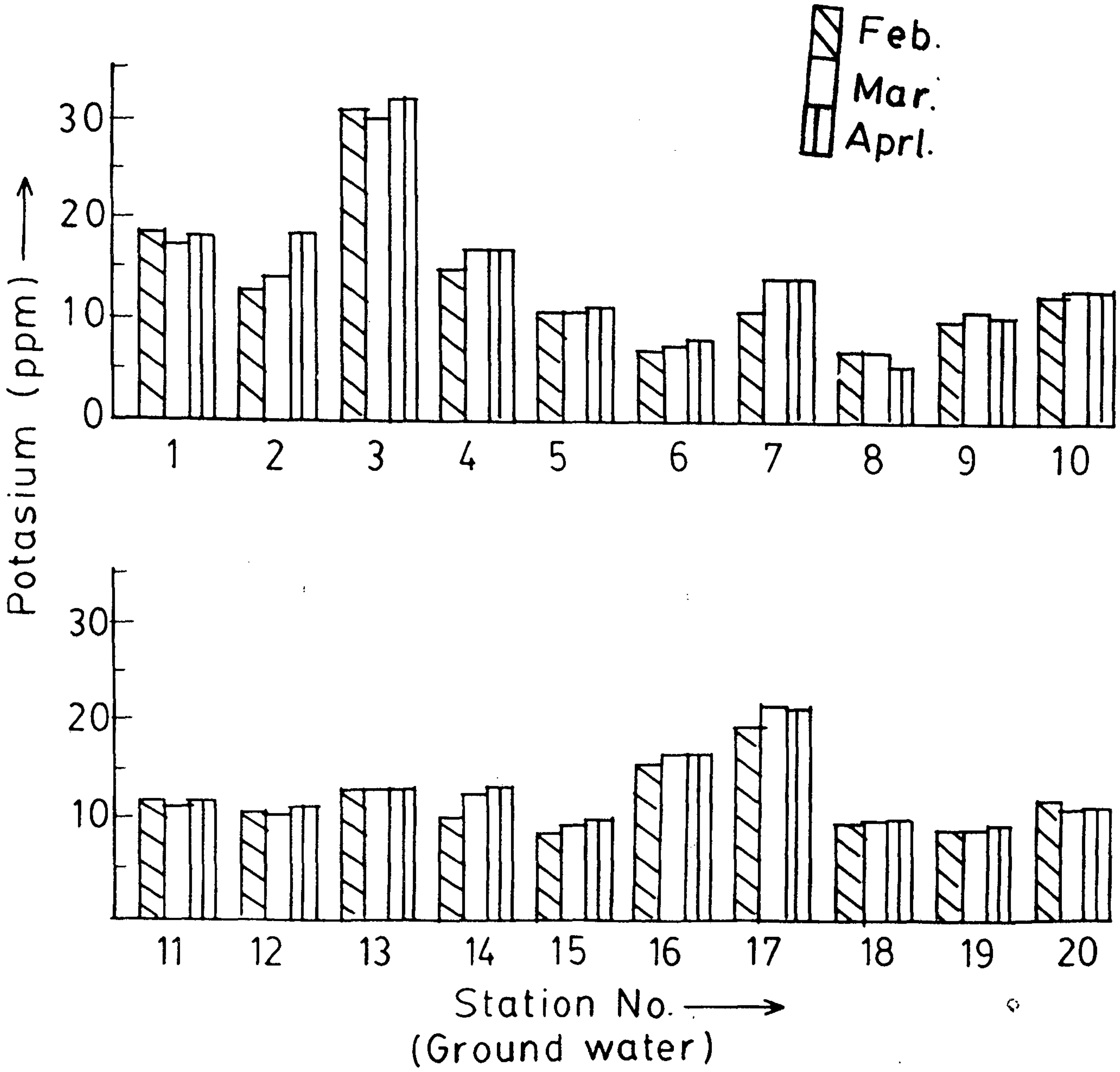
I - Samples of partially treated sewage
II - Samples of slurry water
III - Samples of ground water



23.a. Periodical variation of potassium in partially treated sewage water collected from different stations.



23.b. Periodical variation of potassium in slurry water collected from different stations.



23.b. Periodical variation of potassium in groundwater collected from different stations.

TOTAL COLIFORMS COUNT OF THE PARTIALLY TREATED SEWAGE AT DIFFERENT STATIONS

[MPN/100 ml]

Stations	Period Feb	 Mar	 Apr
1.	2400	2400	2400
2.	2400	2400	2400
3.	2400	2400	2400
4.	920	1600	1600

TOTAL COLIFORMS COUNT OF THE SLURRY AT VARIOUS POINTS OF THE ASH POND

[MPN/100 ml]

TOTAL COLIFORM COUNT OF GROUNDWATER AT VARIOUS STATIONS

[MPN/100 ml]

Stations	Period Feb	Mar	Apr	Average
1.	6	8	6	
2.	4	10	10	
3.	920	540	920	
4.	14	12	16	
5.	28	35	32	
6.	59	62	69	
7.	41	47	45	
8.	27	33	29	
9.	17	19	23	
10.	12	17	21	
11.	31	33	33	
12.	40	47	64	
13.	110	180	140	
14*.	540	920	920	
15.	70	95	81	
16.	79	95	110	
17.	36	36	42	
18.	19	22	17	
19.	110	130	130	
20*.	350	430	430	

*Open Dug Wells

Pb CONTENT IN PARTIALLY TREATED SEWAGE WATER AT DIFF STATIONS OF ITS FLOW

[In ppb]

Stations	Period Feb	 Mar	 Apr	 Average
1.	10.62	13.81	23.73	16.10±6.80
2.	19.70	18.86	26.53	21.70±4.20
3.	N.D.	2.86	1.76	2.31±0.78
4.	43.05	48.56	23.73	38.40±13.00

Pb CONTENT OF SLURRY AT DIFF. POINTS OF SLURRY

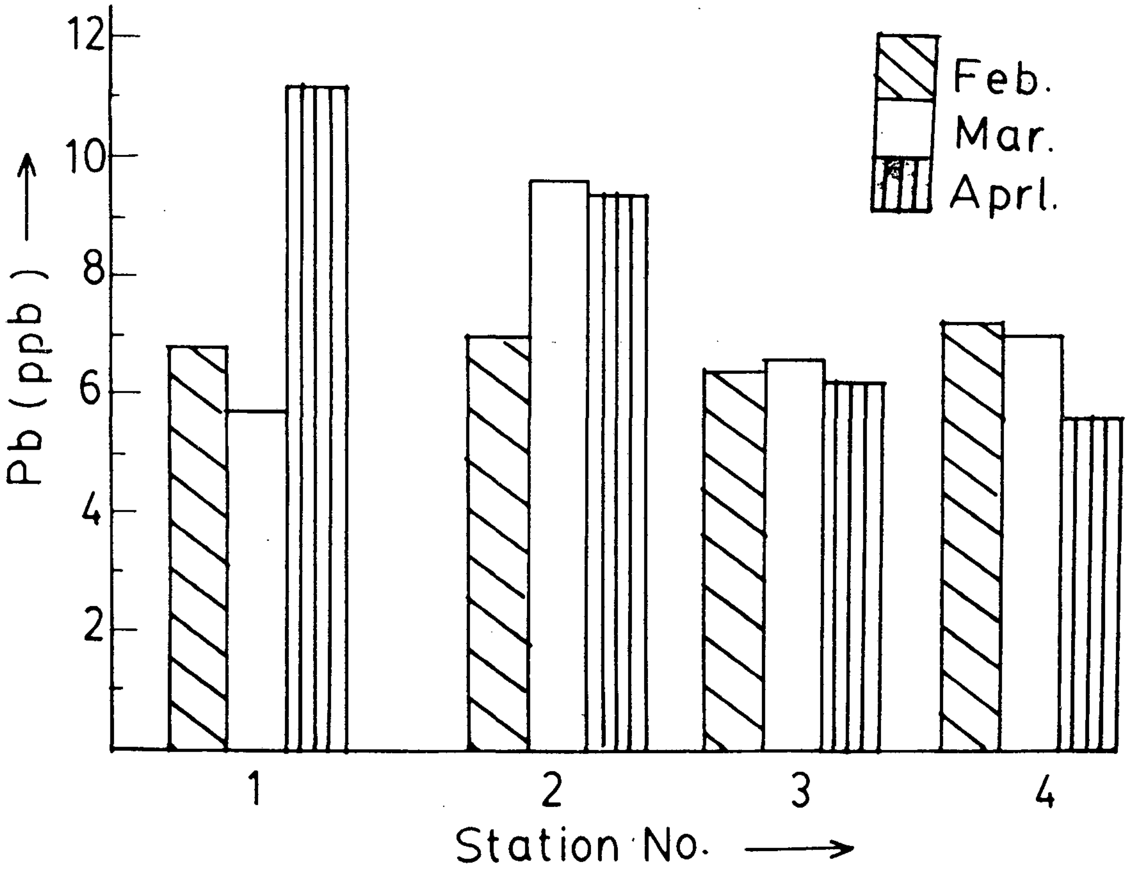
[In ppb]

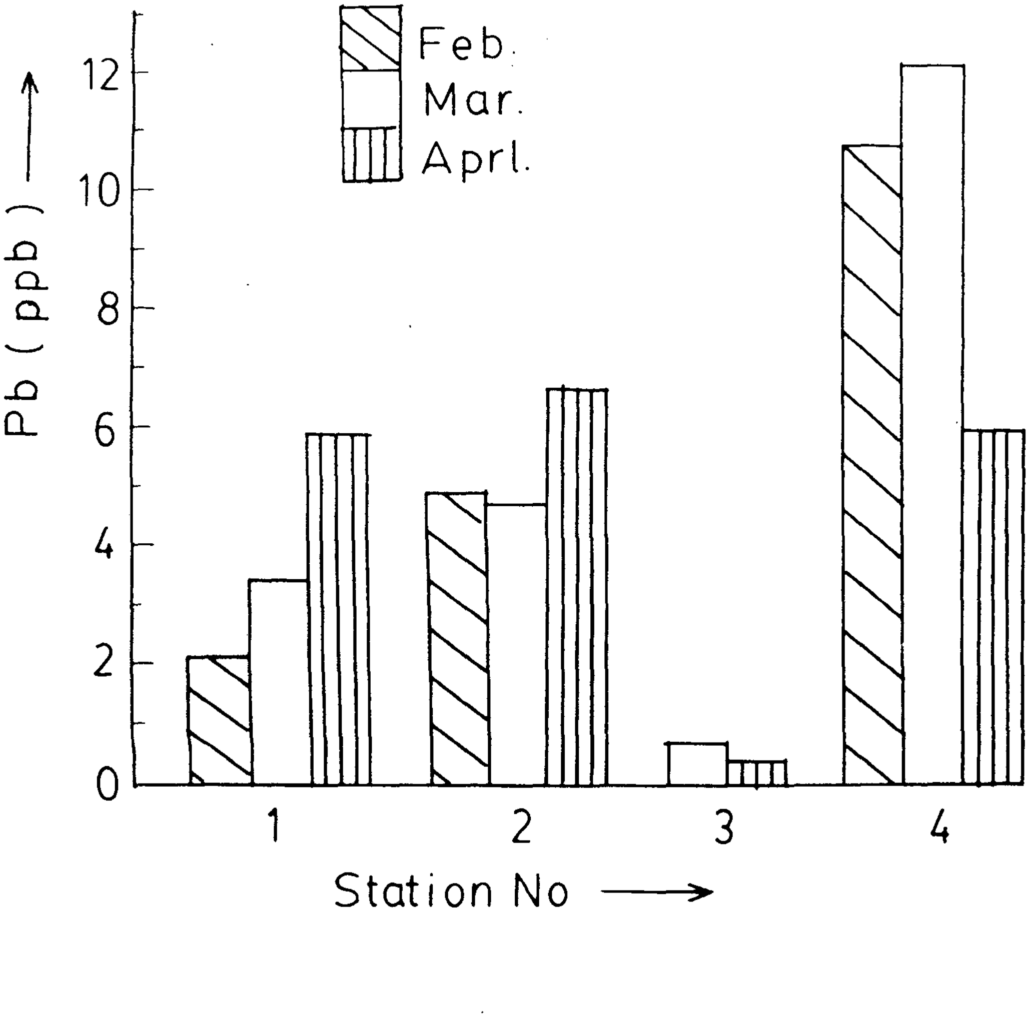
Stations	Period Feb	 Mar	 Apr	 Average
1.	3.42	2.86	5.62	3.97±1.46
2.	3.51	4.82	4.76	4.36±0.74
3.	3.20	3.26	3.19	3.22±0.04
4.	3.67	3.56	2.87	3.37±0.43

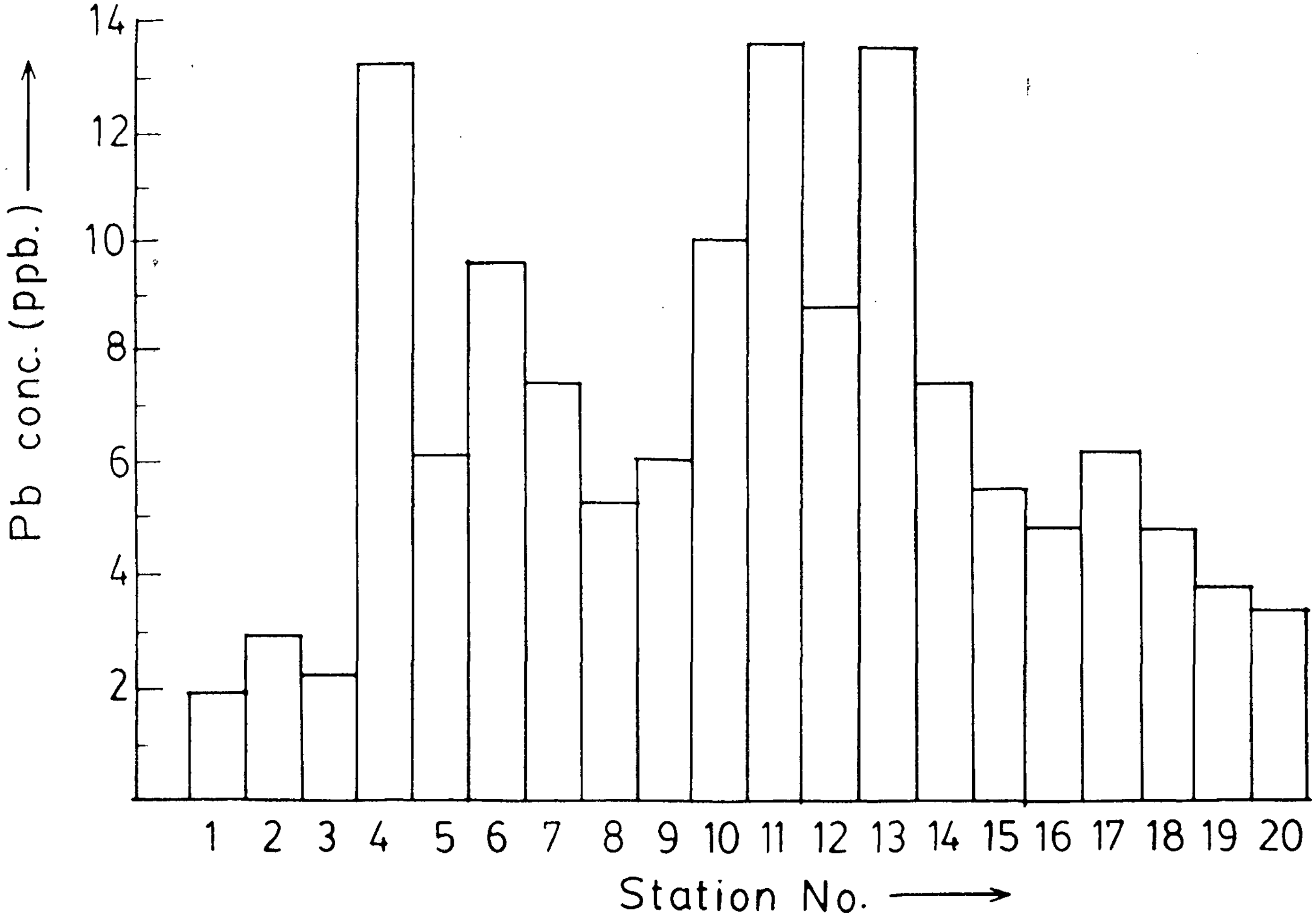
Pb CONTENT OF GROUND WATER
AT DIFFERENT STATIONS

[In ppb]

Stations	Period			
	Feb	Mar	Apr	Average
1.	6.832	10.891	5.83	7.85±2.68
2.	10.32	12.86	12.73	11.97±1.43
3.	6.56	10.86	8.75	8.72±2.15
4.	49.12	56.62	48.22	53.75±2.06
5.	38.63	40.72	36.61	24.46±5.22
6.	25.72	28.93	18.72	
7.	32.50	40.86	42.16	38.50±5.24
8.	31.10	28.35	29.55	29.70±1.38
9.	18.76	25.76	19.02	21.20±3.98
10.	23.85	28.18	20.17	24.07±4.01
11.	45.27	40.08	35.55	40.30±4.86
12.	5.78	6.82	6.98	6.53±3.77
13.	65.67	57.22	50.84	87.9±7.44
14.	36.96	30.02	39.91	35.60±5.08
15.	49.92	58.00	52.54	53.49±18.6
16.	26.82	30.08	32.07	29.66±2.65
17.	21.28	26.82	18.46	22.19±4.25
18.	22.83	20.15	17.29	19.76±8.31
19.	20.12	28.65	27.52	25.40±4.63
20.	14.56	18.72	11.59	14.96±3.58


12
10
8
6
4
2
Pb (ppb) →
Feb.
Mar.
Aprl.
1
2
3
4
Station No. →


Feb.
Mar.
Aprl.
Pb (ppb) →
0
2
4
6
8
10
12
1
2
3
4
Station No →



27.c. Average value of lead in groundwater collected from different stations.

Zn CONTENT OF PARTIALLY TREATED SEWAGE WATER AT DIFFERENT STATIONS OF FLOW

[In ppb]

Stations	Period Feb	Mar	Apr	Average
1.	17.28	18.06	17.92	
2.	11.76	12.06	12.19	
3.	2.046	1.982	1.90	
4.	35.25	39.12	37.65	

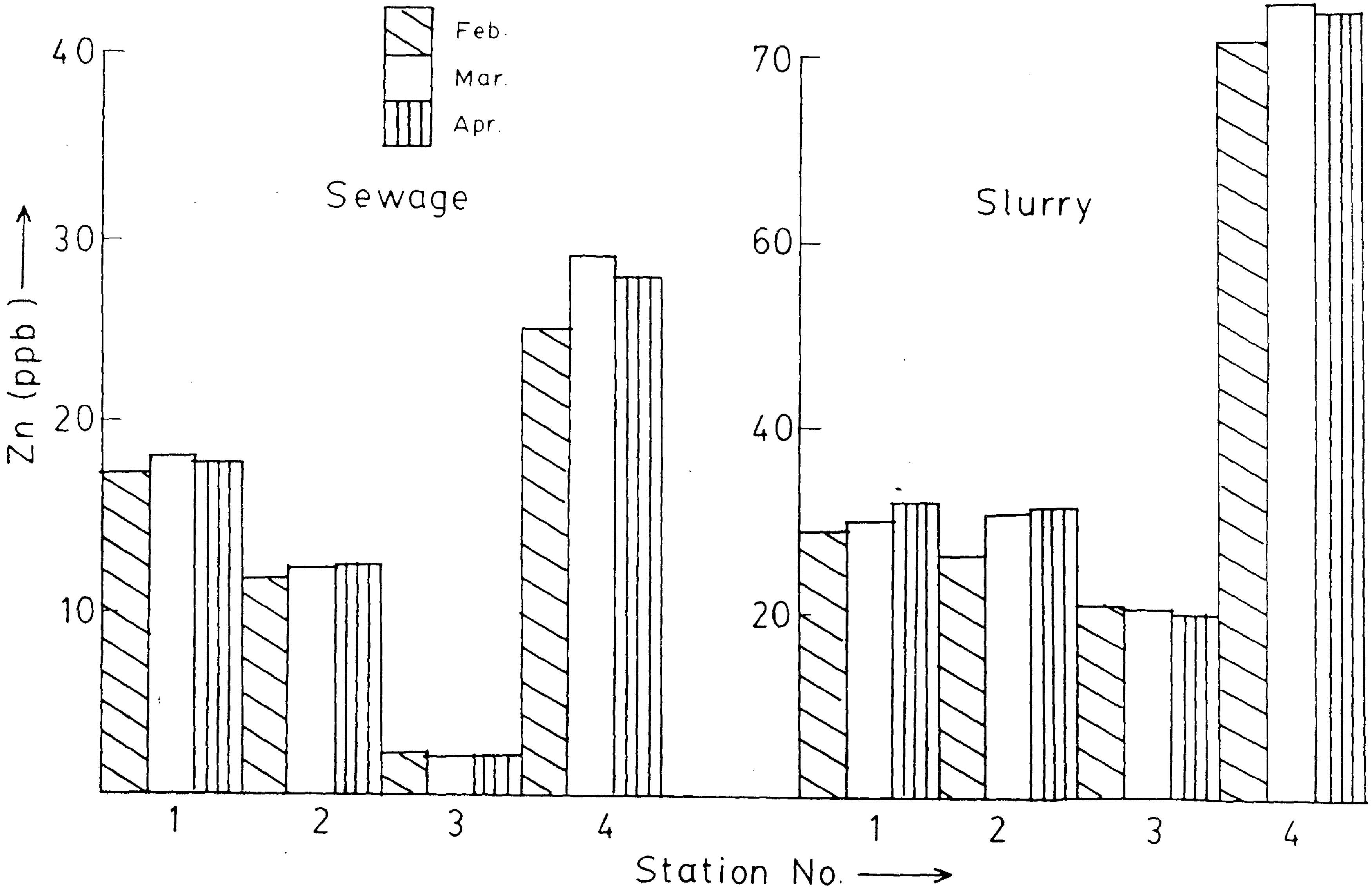
Zn CONTENT OF SLURRY AT DIFFERENT STATIONS OF ASH POND

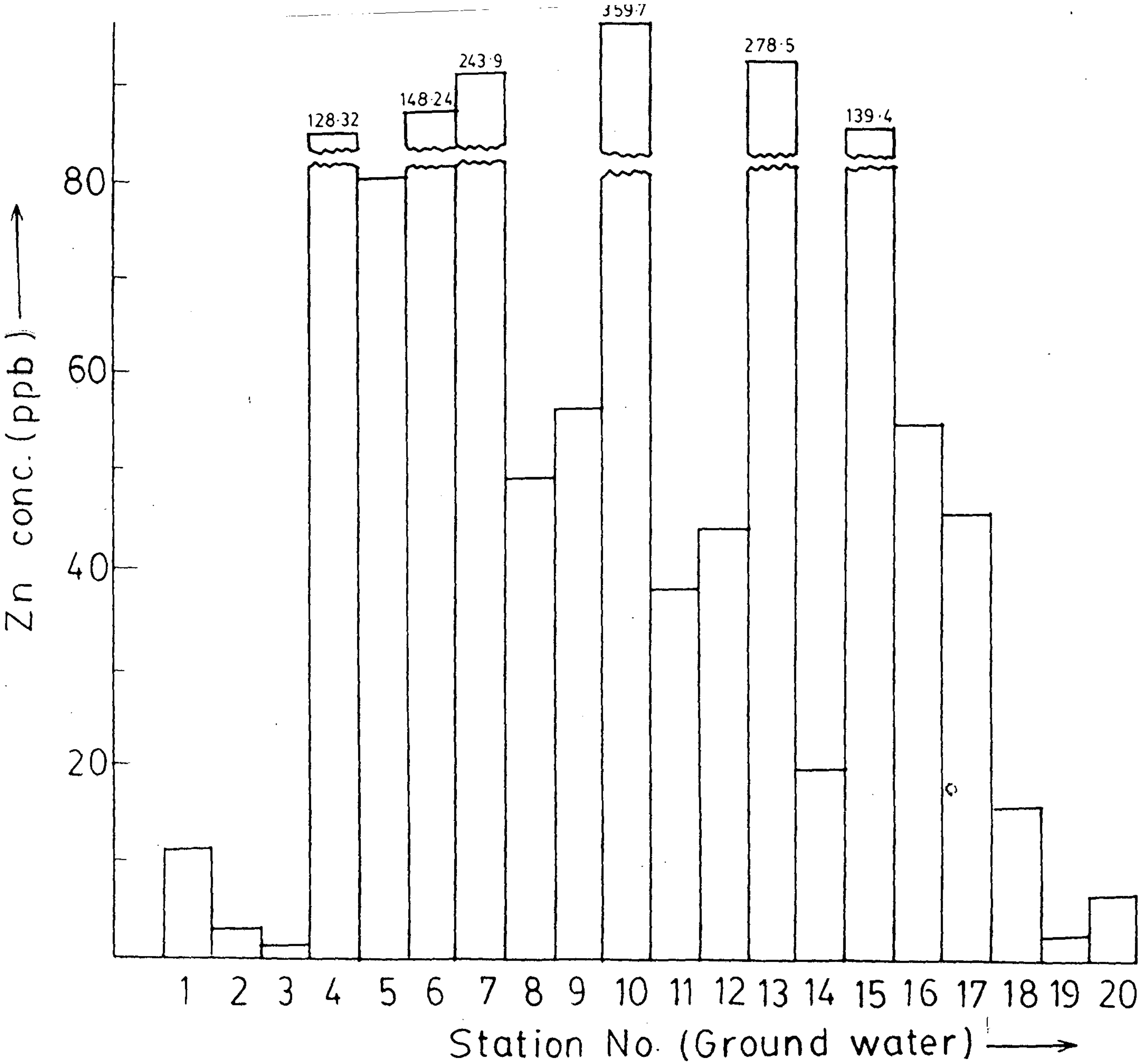
Stations	Period Feb	Mar	Apr	Average
1.	28.92	30.00	32.125	
2.	26.34	31.12	31.46	
3.	20.80	20.73	20.13	
4.	72.00	76.13	75.16	

Zn CONTENT OF GROUND WATER SAMPLES AT DIFFERENT STATIONS

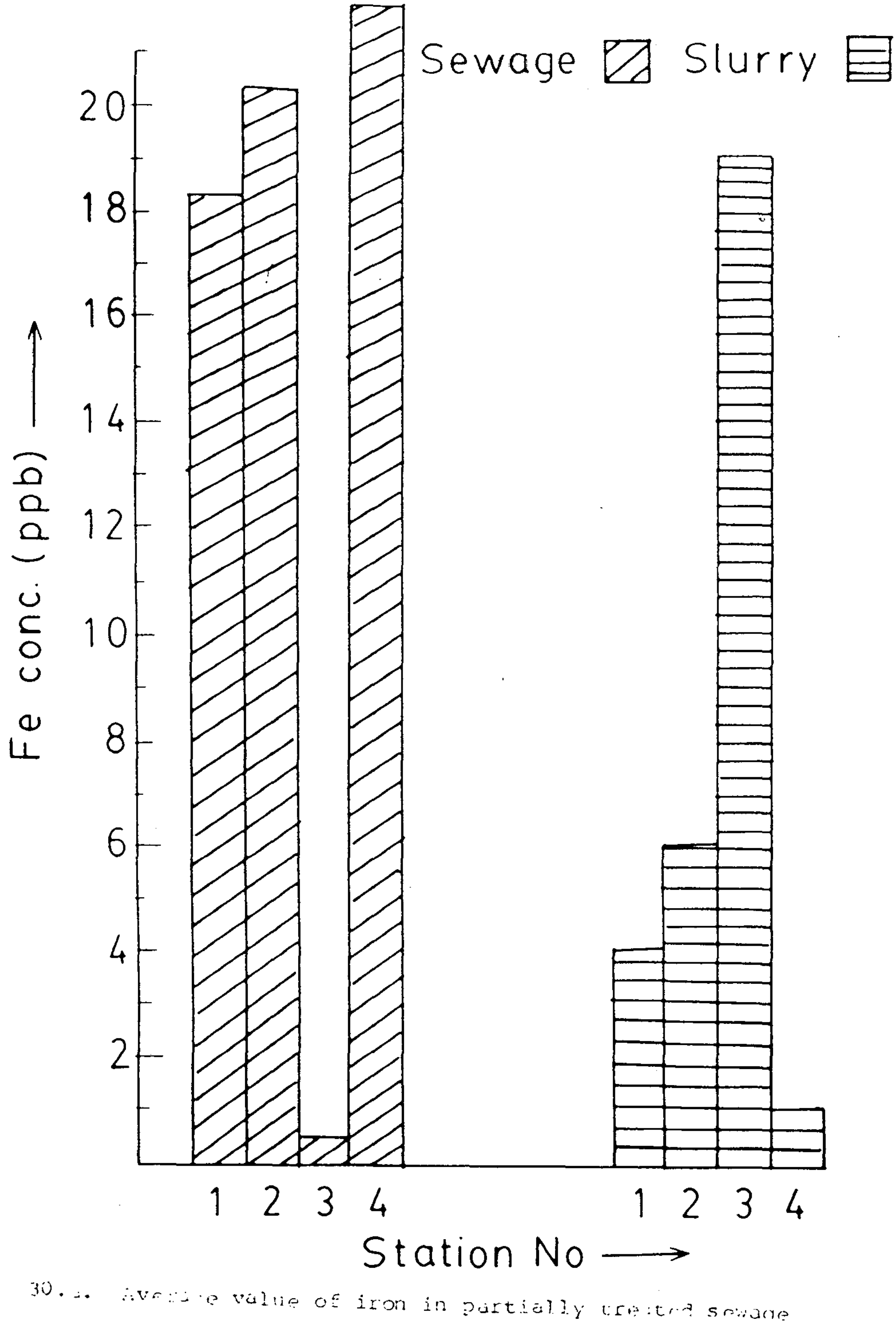
[In ppb]

Stations	Period Feb	Mar	Apr	Average
1.	10.53	12.76	10.82	11.37±12.12
2.	2.49	2.86	2.95	2.80±.24
3.	1.04	0.92	1.13	1.03±.10
4.	132.75	128.6	123.61	128.32±4.6
5.	79.20	82.26	80.16	80.54±1.6
6.	140.25	156.12	148.35	148.24±7.9
7.	235.00	246.52	250.112	243.90±7.9
8.	45.4	50.15	52.72	49.40±3.7
9.	52.64	60.18	56.72	56.50±3.8
10.	382.5	350.12	346.56	359.70±19.8
11.	32.40	40.182	42.62	38.40±5.3
12.	43.52	45.126	44.34	44.32±0.8
13.	280.50	276.40	278.63	278.50±2.05
14.	18.56	20.182	20.622	19.80±1.1
15.	137.39	140.46	140.221	139.40±1.7
16.	58.62	60.12	46.73	55.20±7.3
17.	42.49	49.17	45.94	45.90±3.3
18.	13.42	17.04	17.29	15.9±2.2
19.	2.86	1.962	2.27	2.40±.5
20.	6.73	6.921	6.56	6.70±.2

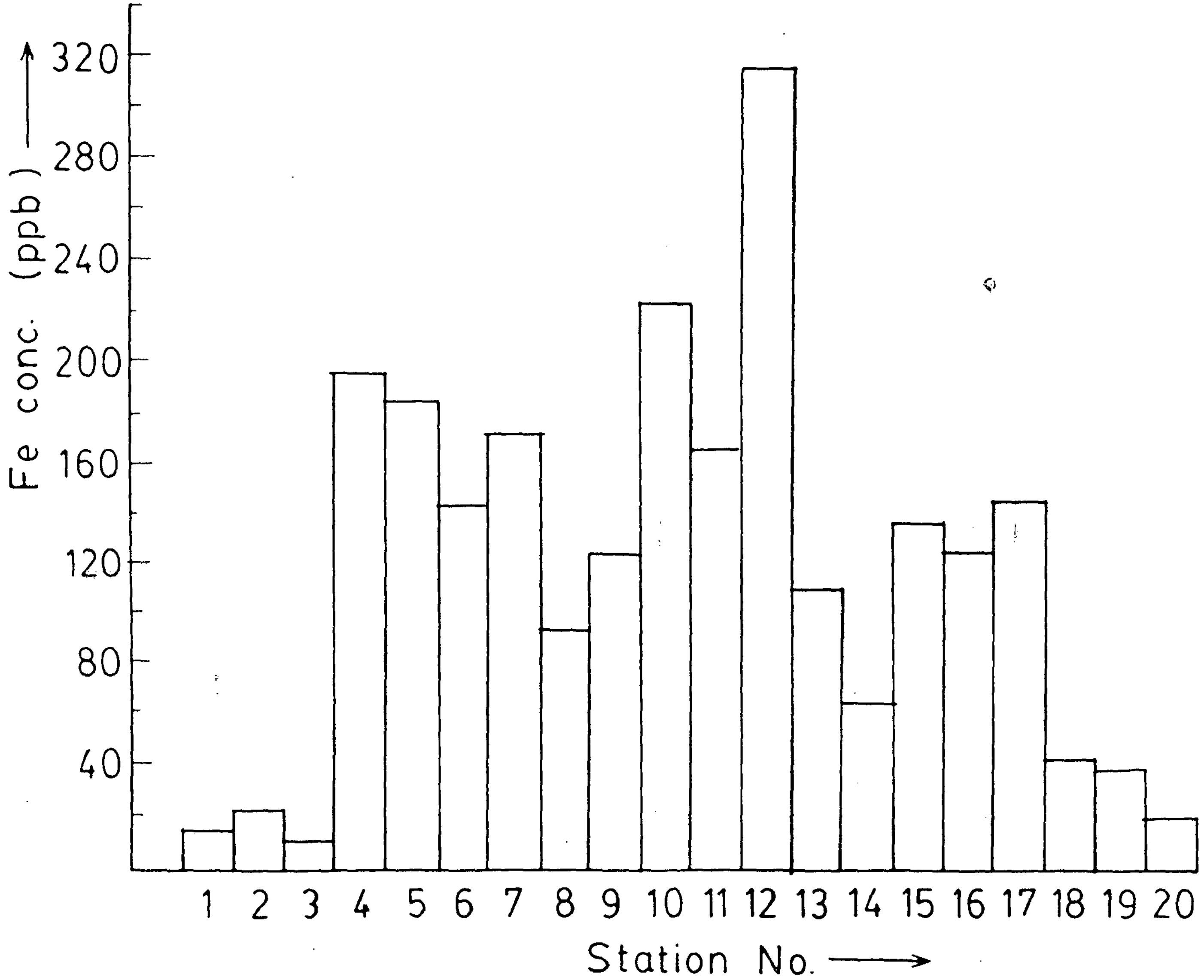
Feb.
Mar.
Apr.
Sewage
Slurry
Zn (ppb) →
40
30
20
10
70
60
40
20
1
2
3
4
1
2
3
4
Station No. →



28.c. Average value of zinc in groundwater collected from different stations.



30.a. Average value of iron in partially treated sewage n. in slurry water collected from different stations.



30.c. Average value of iron in groundwater collected from different stations.

Fe CONTENT OF PARTIALLY TREATED SEWAGE WATER AT DIFF STATIONS OF ITS FLOW

[In ppb]

Stations	Period Feb	Mar	Apr	Average
1.	289.8	176.5	82.72	183.0±103.70
2.	219.0	211.66	180.82	203.80±203
3.	9.438	19.720	12.45	13.87±5.29
4.	183.9	186.72	287.26	218.92

Stations	Period Feb	Mar	Apr	Average
1.	102.6	121.56	144.681	122.9±21.1
2.	206.7	186.66	158.82	184.10±24.0
3.	573.5	472.87	680.82	575.70±104.0
4.	13.39	49.72	28.65	30.60±18.2

Fe CONTENT IN GROUND WATER
FROM DIFFERENT SAMPLING STATIONS

[In ppb]

Stations	Period			
	Feb	Mar	Apr	Average
1.	15.568	18.70	12.87	15.70±2.92
2.	20.826	26.63	18.72	22.10±4.1
3.	10.88	8.72	9.83	9.81±1.08
4.	199.25	210.31	180.88	196.80±14.9
5.	179.332	205.7	186.25	
6.	123.45	133.25	186.50	147.70±33.9
7.	165.60	180.29	172.9	
8.	87.15	110.82	89.22	95.70±13.1
9.	110.32	148.18	126.34	128.30±19.0
10.	205.20	250.10	230.80	228.70±22.5
11.				
12.	303.96	346.12	309.65	319.90±22.9
13.	106.59	118.72	120.55	
14.	68.96	66.01	65.7	66.80+
15.	118.14	156.82	142.72	139.20±19.6
16.	146.60	120.06	116.42	127.70±16.5
17.	118.44	118.06	136.60	145.00±31.70
18.	56.82	54.00	42.06	145.00±31.7
19.	45.46	42.92	56.08	41.50±15.3
20.	22.88	28.82	19.36	23.70±4.8

Cd CONTENT OF SEWAGE

[In ppb]

Stations	Period			
	Feb	Mar	Apr	Average
1.	1.26	01.36	0.921	1.147±0.45
2.	0.25	0.48	0.172	0.300±0.16
3.	0.858	0.682	1.002	0.847±0.16
4.	2.184	1.86	1.25	1.76±0.47

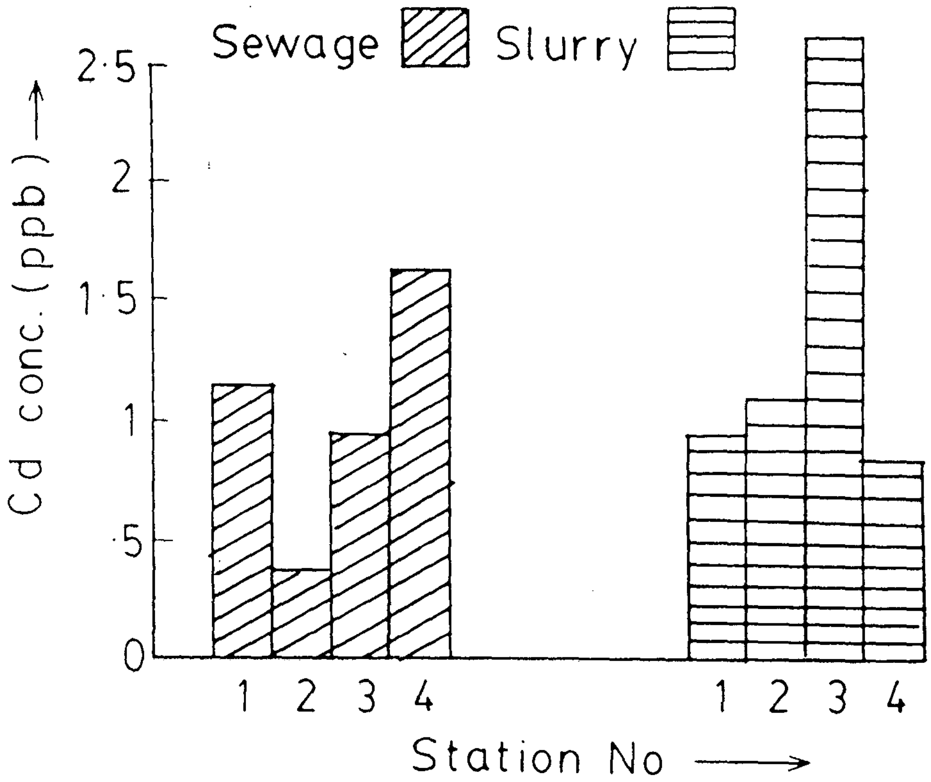
Cd CONTENT OF SLURRY

Stations	Period			
	Feb	Mar	Apr	Average
1.	1.71	0.29	0.872	0.957±0.71
2.	1.66	0.87	1.25	1.26±0.40
3.	2.2	2.96	3.06	2.74±0.47
4.	1.08	0.560	0.980	0.873±0.28

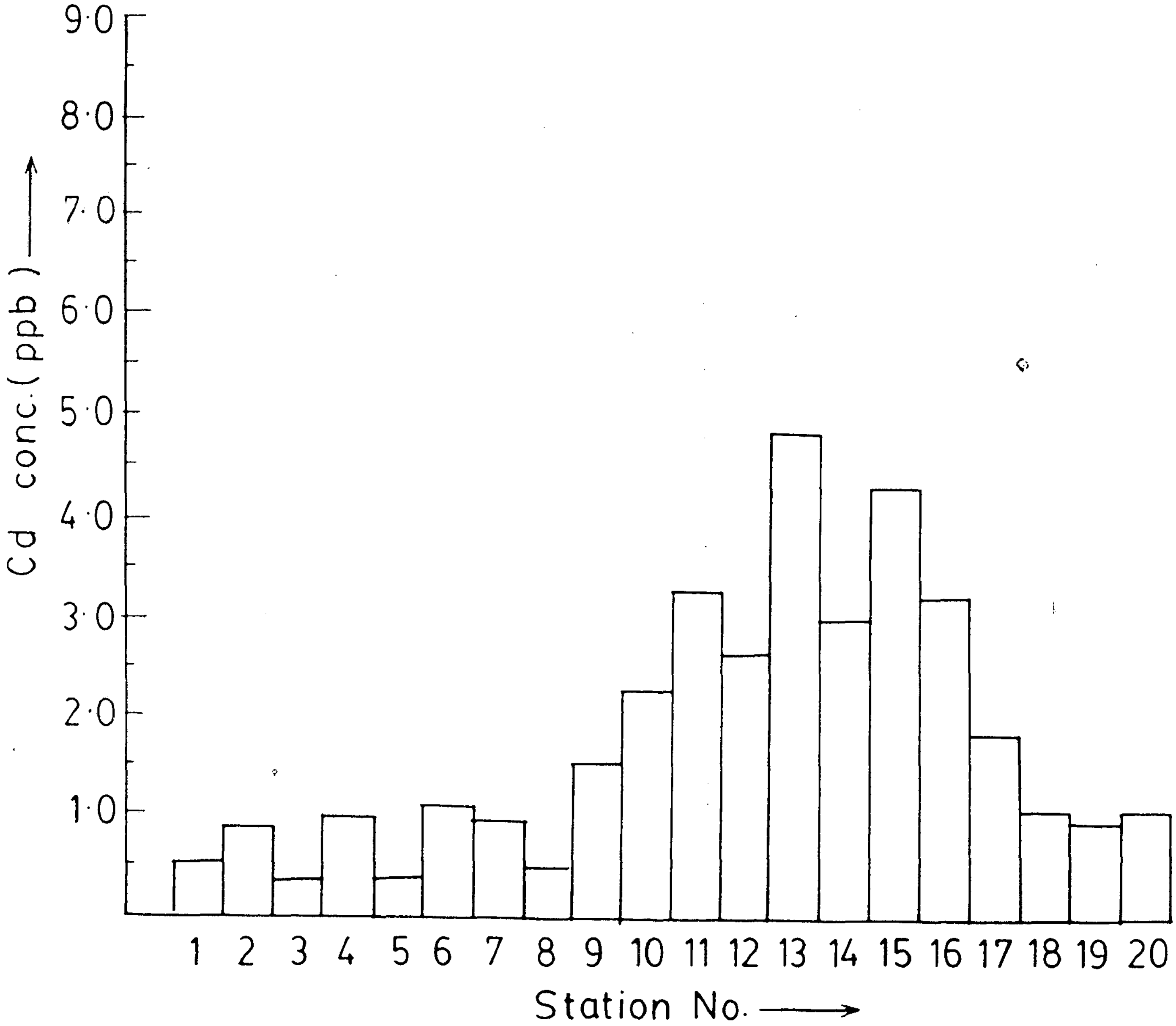
Cd CONTENT OF GROUNDWATER

[In ppb]

Stations	Period Feb	 Mar	 Apr	Average
1.	0.448	0.68	0.39	0.506±0.15
2.	0.89	0.76	0.86	0.837±0.07
3.	0.48	0.21	0.32	0.337±0.14
4.	0.75	1.17	0.98	0.967±0.21
5.	0.264	0.58	0.172	0.339±0.21
6.	0.525	1.71	1.083	1.106±0.59
7.	1.00	0.872	0.831	0.934±0.32
8.	0.40	0.421	0.517	0.496±0.20
9.	0.98	1.71	1.81	1.53±0.92
10.	2.475	1.86	01.732	2.289±0.88
11.	3.96	2.88	2.962	3.27±0.60
12.	2.31	01.98	2.88	2.66±0.98
13.	6.105	3.72	4.83	4.89±1.19
14.	3.20	2.78	2.931	2.97±0.21
15.	3.96	4.06	4.86	4.29±0.49
16.	2.48	3.06	3.13	3.22±0.83
17.	1.47	2.17	1.83	1.82±0.35
18.	1.28	0.962	0.988	1.08±0.80
19.	0.875	0.996	0.920	0.93±0.06
20.	0.650	0.872	1.73	1.08±0.57



Average value of cadmium



32.c. Average value of cadmium in groundwater collected from different stations.

Cu CONTENT OF PARTIALLY TREATED SEWAGE AT DIFFERENT STATIONS OF FLOW

[In ppb]

Stations	Period Feb	 Mar	 Apr	Average
1.	8.28	4.82	11.79	8.30±3.49
2.	11.50	9.22	17.09	12.60±4.05
3.	3.234	0.98	2.85	2.35±1.21
4.	14.768	12.58	16.86	14.17±6.18

Cu CONTENT OF SLURRY AT DIFFERENT POINTS OF ASH/POND

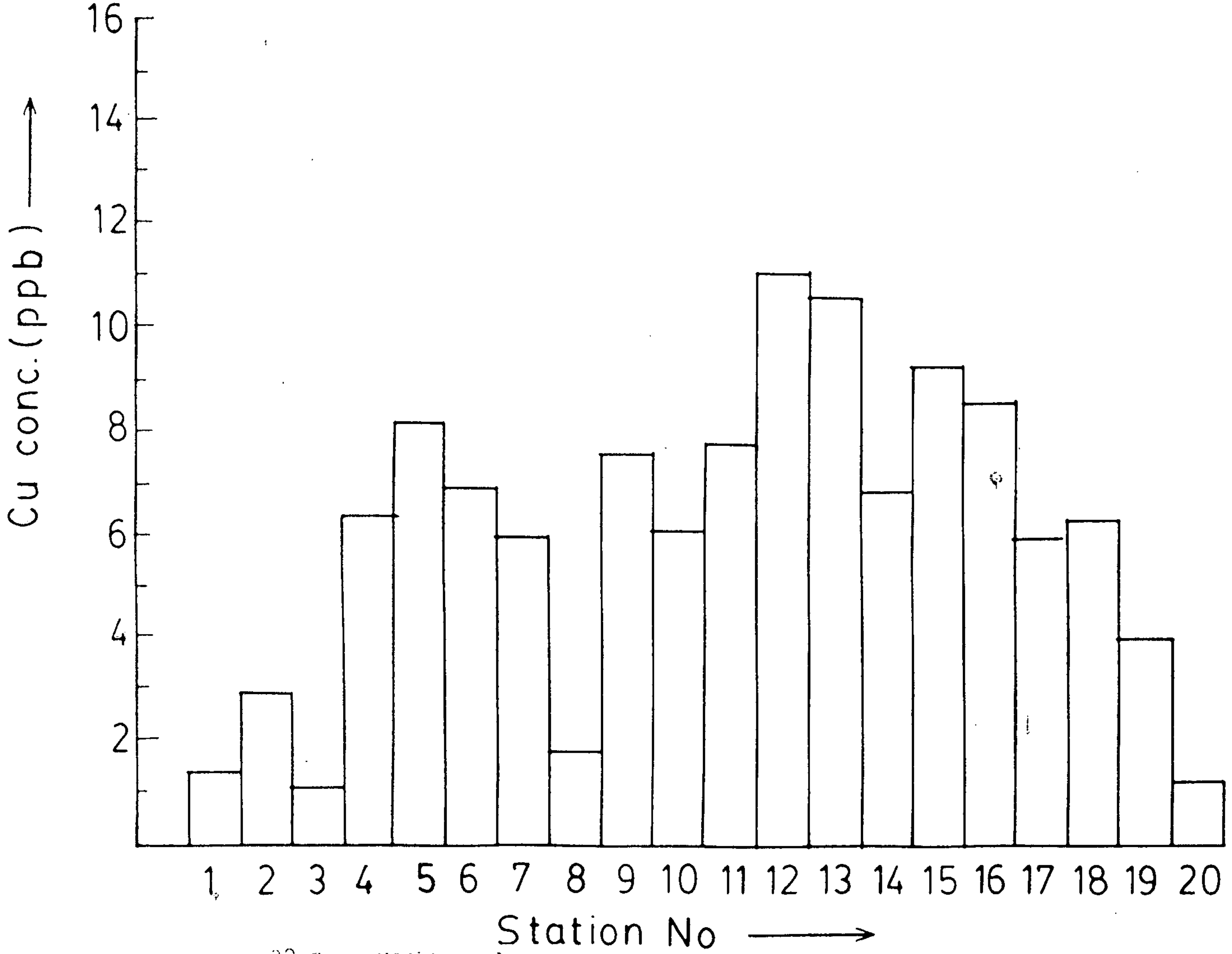
[In ppb]

Stations	Period Feb	 Mar	 Apr	Average
1.	5.89	6.06	8.11	7.69
2.	6.87	7.22	5.29	6.46±1.03
3.	8.40	3.76	4.09	5.42±2.59
4.	1.44	2.72	2.98	2.38±0.82

Cu CONTENT OF GROUND WATER

[In ppb]

Stations		Period		
	Feb	Mar	Apr	Average
1.	1.68	0.98	1.22	1.29±0.36
2.	2.136	3.81	2.721	2.89±0.85
3.	1.36	0.920	0.876	1.05±0.27
4.	7.00	3.05	9.14	6.40±3.09
5.	7.48	4.14	12.93	8.18±4.44
6.	5.55	8.87	6.25	6.89±1.75
7.	6.00	5.83	5.96	5.96±1.24
8.	2.80	0.921	1.760	1.83±0.94
9.	5.04	8.921	8.763	7.57±2.20
10.	6.30	6.22	5.91	6.14±0.20
11.	8.28	7.05	7.98	7.77±0.64
12.	10.88	12.52	9.92	11.11±1.31
13.	9.405	10.03	10.42	10.62±4.71
14.	5.60	7.08	8.02	6.90±1.22
15.	8.03	10.26	9.64	9.31±1.15
16.	7.85	8.25	8.75	8.62±2.95
17.	6.3	4.43	7.19	5.97±1.41
18.	5.86	6.36	6.47	6.23±0.33
19.	4.112	4.00	5.95	4.02±1.94
20.	2.73	2.733	2.09	2.70±1.02



29.c. Average value of copper in groundwater collected from different stations.

Mn CONTENT OF PARTIALLY TREATED SEWAGE WATER AT DIFFERENT STATIONS OF FLOW

[In ppb]

Stations	Period			
	Feb	Mar	Apr	Average
1.	63.72	28.79	30.83	41.10±19.6
2.	29.20	30.34	46.50	35.30±9.68
3.	1.452	1.78	0.923	1.39±0.43
4.	49.088	60.081	46.83	52.00±7.89

Mn CONTENT OF SLURRY

Stations	Period			
	Feb	Mar	Apr	Average
1.	60.838	58.21	67.27	62.1±4.66
2.	28.36	30.07	32.09	30.20±1.87
3.	19.60	28.18	14.55	20.80±6.89
4.	1.452	0.983	1.320	1.250±.24

Mn CONTENT OF GROUND WATER SAMPLES OF DIFFERENT STATIONS

[In ppb]

Stations	Period			
	Feb	Mar	Apr	Average
1.	2.688	2.08	1.971	2.25±0.39
2.	4.094	3.70	4.21	4.00±0.27
3.	1.920	0.92	0.96	1.27±0.57
4.	24.00	32.21	28.72	28.30±4.12
5.	16.10	10.45	18.72	15.10±4.23
6.	34.27	40.82	40.72	38.60±3.75
7.	20.00	18.25	19.78	19.30±0.95
8.	19.70	26.36	17.16	21.10±4.75
9.	261.24	182.2	196.10	213.20±42.2
10.	225.45	186.81	232.2	214.80±24.5
11.	47.79	30.48	51.16	43.10±11.1
12.	33.66	38.73	39.22	40.20±7.98
13.	27.72	18.83	19.17	21.90±5.04
14.	7.36	10.00	9.34	8.901±37
15.	56.10	42.25	38.73	45.70±9.18
16.	42.90	46.65	49.15	46.2±3.15
17.	56.10	50.09	38.55	54.90±4.35
18.	8.26	10.87	12.83	10.70±2.29
19.	3.937	4.07	4.125	4.04±0.10
20.	3.51	0.725	1.035	1.76±1.53

Ni CONTENT IN PARTIALLY TREATED SEWAGE AT DIFFERENT STATIONS OF FLOW

[In ppb]

Stations	Period Feb	 Mar	 Apr	Average
1.	9.00	8.72	8.82	
2.	2.00	1. 93	1.86	
3.	5.016	4.92	5.22	
4.	21.32	23.76	23.14	

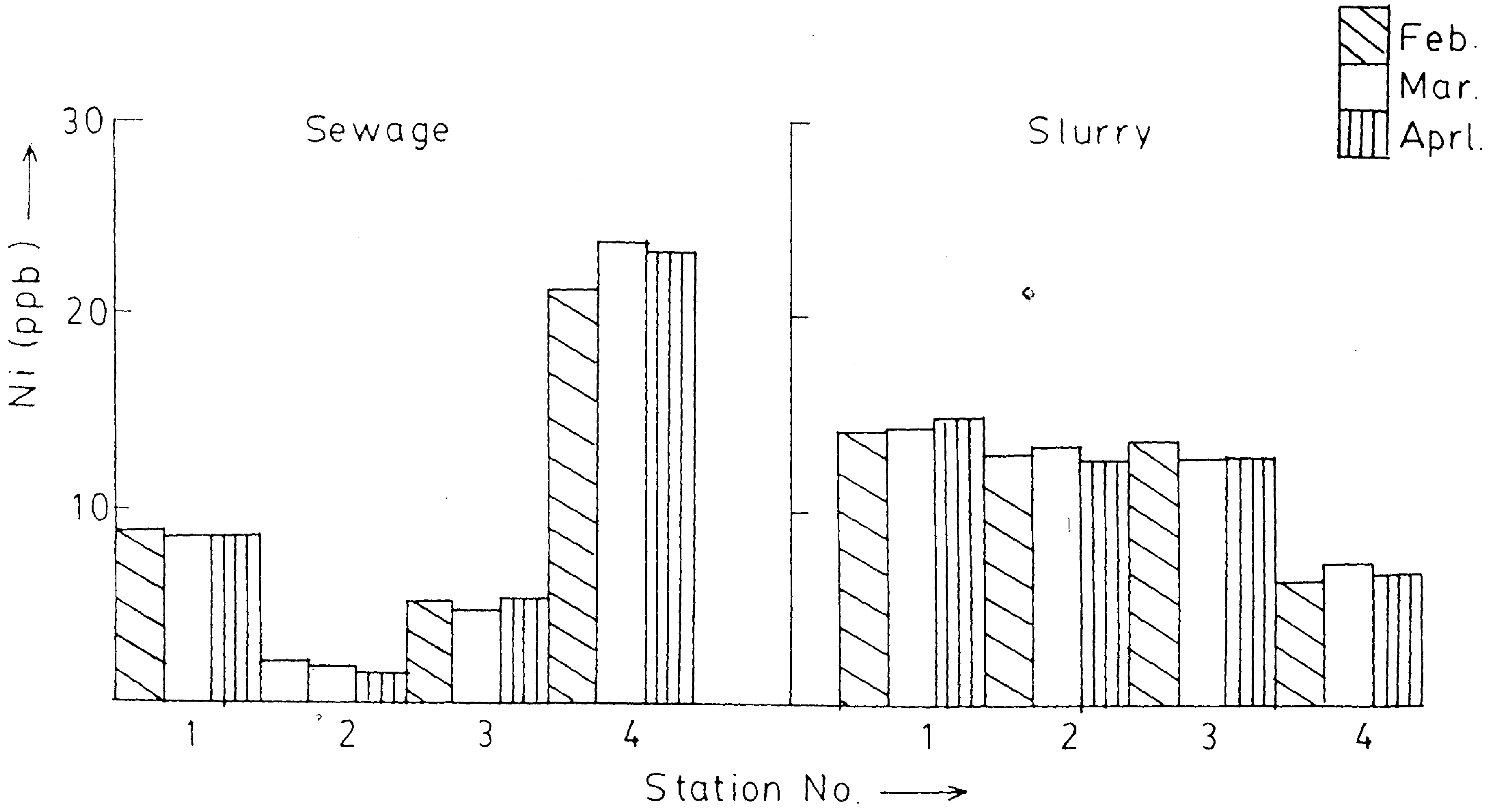
Ni CONTENT OF SLURRY AT DIFFERENT POINTS OF ASH POND

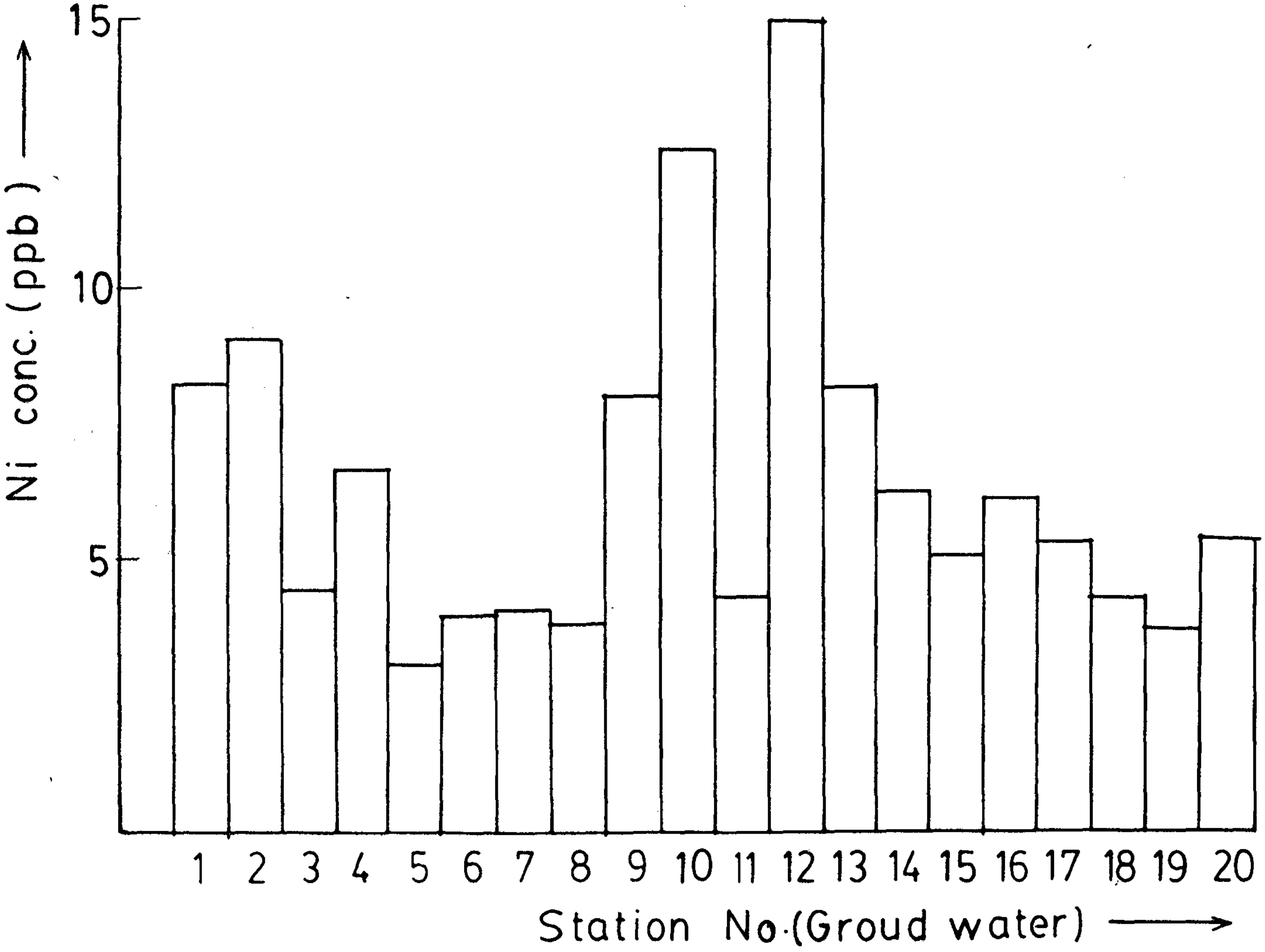
Stations	Period Feb	 Mar	 Apr	Average
1.	13.90	14.12	14.86	
2.	12.96	13.12	12.85	
3.	13.30	12.76	12.85	
4.	6.34	7.12	6.92	

Ni OF GROUND WATER

[In ppb]

Stations	Period Feb	Mar	Apr	Average
1.	8.512	7.10	9.21	8.30±1.1
2.	9.612	8.75	8.82	9.06±.5
3.	3.92	4.03	4.16	4.04±.12
4.	6.50	7.12	6.25	6.62±.44
5.	2.728	3.16	3.26	3.04±.3
6.	3.825	4.10	4.02	3.90±.14
7.	4.75	3.09	4.28	4.04±.85
8.	3.85	4.162	3.29	3.77±.44
9.	7.70	8.11	8.16	7.99±.25
10.	13.50	10.82	13.35	12.55±1.5
11.	4.68	3.95	4.162	4.26±.37
12.	15.64	14.92	14.28	14.94±.68
13.	7.76	8.86	8.0221	8.21±.57
14.	6.396	6.116	6.20	6.23±.14
15.	4.84	5.12	5.26	5.07±.21
16.	5.86	6.17	6.23	6.08±.19
17.	4.92	5.21	5.86	5.33±.48
18.	3.83	4.32	4.76	4.30±.47
19.	3.50	3.82	3.79	3.70±.17
20.	5.20	4.74	5.92	5.30±.6


Feb.
Mar.
Aprl.
Sewage
Slurry
Ni (ppb) →
30
20
10
1
2
3
4
1
2
3
4
Station No. →



33.c. Average value of nickel in groundwater collected from different stations.

DISCUSSIONS AND CONCLUSIONS

DISCUSSION

The importance of ground water as the readily available, accessible and the most acceptable source of water in terms of potability and aesthetic values, has been recognised since long because the surface water sources pose a host of problems and are much more vulnerable to the agencies of degradation and deterioration in terms of potability criteria.

As the vast population of the third world has not got the luxury of having access to the treated hygienic municipal water supply, 85 % of the rural and 30% of the urban population there, depend upon the sources of ground water for domestic consumption. (WHO 1976). Thus, a sizeable portion of the world population depends on ground water resource to meet the need of water for drinking and civic purposes.

Moreover, 35 % of the water piped by municipalities is drawn from the underground sources (Donald, 1979).

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In the case of Aligaon, under investigation, the entire pupulace is dependent on the ground water for drinking, cooking and other domestic and sanitation purposes.

Quality of the water used for domestic consumption is of paramount importance because the water is the principal medium through which endemic and epidemic diseases break out (Craun, 1975). The chemical and biological contaminants of potable waters can lead to serious health hazards through a number of water borne diseases and body disorders. Ground water is generally assumed to have a good quality. However, contaminants may be introduced to the aquifer through so many modes and septic tank type waste disposal system is one of them (Gerba et al., 1975).

The management and maintenance of the ground water quality and measures to prevent chemical and biological contamination of it become inevitable in view of its use in large scale and concommitant consequences.

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The possible solution to the problem of water contamination in order to maintain the public health and to maintain the quality of ground water, lie mainly in prescription of standards. Drinking water standards for several chemical, heavy metals and bacteriological characteristics have been prescribed by various national, international organisations like U.S.P.H.S., CPHEEO, WHO, ISI, EPA etc. Serious health complications have been observed when the concentration of various chemical constituents and bacterial counts transcends the maximum permissible limits laid down by the standards (Comey, 1945; Shearer et. al., 1971)

Schmidt and Knotck (1970) reported methemoglobinernia in children taking excessive amount of nitrate. The study on well waters of Ajmer showed excessive amount of fluride and the cases of fluorasis and mottled teeth were found in the population who used to consume that water (Bhargava et. al., 1978)

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The present investigation has, therefore, been carried out to characterise the chemical, heavy metals and bacteriological quality of ground waters of an urban village, Ali. Various potability parameters were analysed and matched against the standards prescribed by CPHEEO, WHO, ISA and EPA to determine the degree of potability of these waters. The findings of the investigation have been discussed in the light of their significance in relation to health well-beings.

Results of the investigation showed pH to be within the prescribed limit. A slight monthly variation in pH from well to well was observed.

Electrical conductivity of water samples was found to be within the prescribed limit.

Chemical oxygen demand values are found to be nil or negligible in most of the samples.

The P-alkalinity in all the samples analysis was found to be naught indicating absence of hydroxyl groups in water. The total

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alkalinity is only M-alkalinity and is in appreciable amount in the wells of the middle of the village.

Analysis of water for hardness conclusively showed ´hard-water´ for most of the samples according to V.S.P.H.S criteria. Extremely hard water was found in case of station no. 15.

Chloride showed a wide range of variability. Objectionably high value of chloride is shown in samples of ground water of the station no. 7.

The high chloride value accompanied with high nitrate value can be indicative of pollution by sewage waste, contamination by animal waste and septic tank (Robertson, 1979).

Extremely high value of nitrate i.e. 136.0 ppm was observed in samples of station no. 7 where chloride value also was high i.e. 518.60 ppm and thus indicates sewage percolation to the unconfined aquifer - most likely from a septic

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tank. The trend of nitrate variation is non-uniform.

WHO has prescribed 0.02 to 0.4 ppm of phosphate as standard and in most of the samples show high content of phosphorus. Ground waters of hand pump nos. 10, 15, etc. show phosphate levels which are beyond the prescribed limit.

The sulphate content in most of the samples are within the prescribed limit but in the case of a few it is higher.

The value of potassium and silica also seem to be within the limit of reasonability. But one can not predict exact toxicity because their prescribed limit is not mentioned.

There are three sampling stations i.e. 10, 13, and 20 which contain more than 1.00 ppm of fluoride and fluorosis can be expected there, though the clinical symptoms were not ascertained.

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The analysis of heavy metals / trace elements gives a mosaic picture. The Cu, Ni, Cd and Pb contents in all the samples are below the maximum permissible limits.

In case of Zn, Fe and Mn a few wells show the levels of one or more than one of the above heavy metals to be more than that of permissible limit.

The contamination in terms of baceriological parameter is ubiquitous. The hand pump No. 3 which is near to Pump House of the sewage and the open dug wells show high MPN / 100 ml. values.

The above discussion, therefore, leads to the following conclusions :-

1. There is a wide variability in ground water quality of Aligaon and waters of some wells / hand pumps are not safe in terms of chlorides, phosphate, nitrates, nitrites and coliforms bacteria.

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2 The quality of ground waters is by and large determined by the characteristics of the aquifers. The sources of pollutants on the surface of the region seem to play a minor role in comparison.

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APPENDIX

INDIAN STANDARDS INSTITUTE

CHARACTERISTICS FOR DRINKING WATER

SL. No.	SUBSTANCE OR CHARACTERISTIC	REQUIREMENT (DESIREABLE RANGE)
1	2	3
i)	Colour, Hazen Units	Upto to 10
ii)	Odour	Unobjectionable
iii)	Taste	Tasteless
iv)	Turbidity, JTU	Upto 10
v)	Dissolved solids mg/l	Upto 500
vi)	pH value	6.5 ti 8.5
vii)	Copper (as Cu)mg/l	Upto 1.5
viii)	Iron (as Fe)	Upto 0.3
ix)	Chloride (as Cl) mg/l	Upto 250
x)	Sulphate (as SO_4) mg/l	Upto 150
xi)	Nitrate (as NO_3) mg/l	Upto 20
xii)	Fluoride (as F) mg/l	0.6 to 1.0
xiii)	Cadmium (as Cd) mg/l	Upto 0.01
xiv)	Lead (as Pb), mg/l	Upto 0.1
xv)	Zinc (as Zn), mg/l	Upto 5

WORLD HEALTH ORGANIZATION

DRINKING WATER STANDARD*

CHARACTERISTIC	Highest desirable Level	Maximum permissible Level
Total solids	500	1500
Colour (H)	5	50
Taste	Unobjectionable	---
Odour	Unobjectionable	---
Turbidity (Formazin Units)	5	25
Chloride	200	600
Iron	0.1	1
Manganese	0.05	0.5
Copper	0.05	1.5
Zinc	5	15
Calcium	75	200
Magnesium	30	150
Sulphate	200	400
Total Hardness (as $CaCO_3$)	100	500
Nitrate (as NO_3)	45	---
Phenol	0.001	0.002
Anionic detergent	0.02	1.0
Fluoride	0.9-1.7 (mean temp. 12°C) 0.6-0.8 (mean temp. 32°C)	--- ---
pH (units)	7-8	min. 6.5 max. 9.2
Arsenic	-	0.05
Cadmium	-	0.01
Chromium (6+)	-	0.05
Cyanide	-	0.05
Lead	-	0.10
Mercury	-	0.001
Selenium	-	0.01
Polnuclear aromatic Hydrocarbons	-	0.0002
Gross alpha radioactivity (pC/l)	-	3
Gross beta radioactivity (pC/l)	-	30

CONCENTRATION IN mg/l EXCEPT WHERE NOTED.

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* International Standards for Drinking-Water, 3rd ed.. WHO, Geneva, 1971.

APPENDIX-1 DRINKING WATER STANDARDS

	CHARACTERISTIC	Concentrations Accepted	
		CPHEEO*	WHO@
1.	pH	7.0-8.5	7.0-8.5
2.	Total Hardness (mg/l as $CaCO_3$)	200	100
3.	Chlorides (as Cl) (mg/l)	200	200
4.	Sulphates (as SO_4) (mg/l)	200	200
5.	Nitrates (as NO_3) (mg/l)	45	45
6.	Calcium (as Ca)(mg/l)	75	75
7.	Magnesium (as $CaCO_3$) (mg/l)	Not greater than 30.	Not more than 30 mg/l if there are 250 mg/l of sulphates. If there is less sulphate, magnesium upto 150 mg/l may be allowed.
8.	Phosphates (as PO_4) (mg/l)	-	0.02-0.4
9.	Nitrites (as NO_2)(mg/l)	-	0.01
10.	Total coliform	1/100 ml	1/100 ml
11.	*E. coli*.	0/100 ml	0/100 ml

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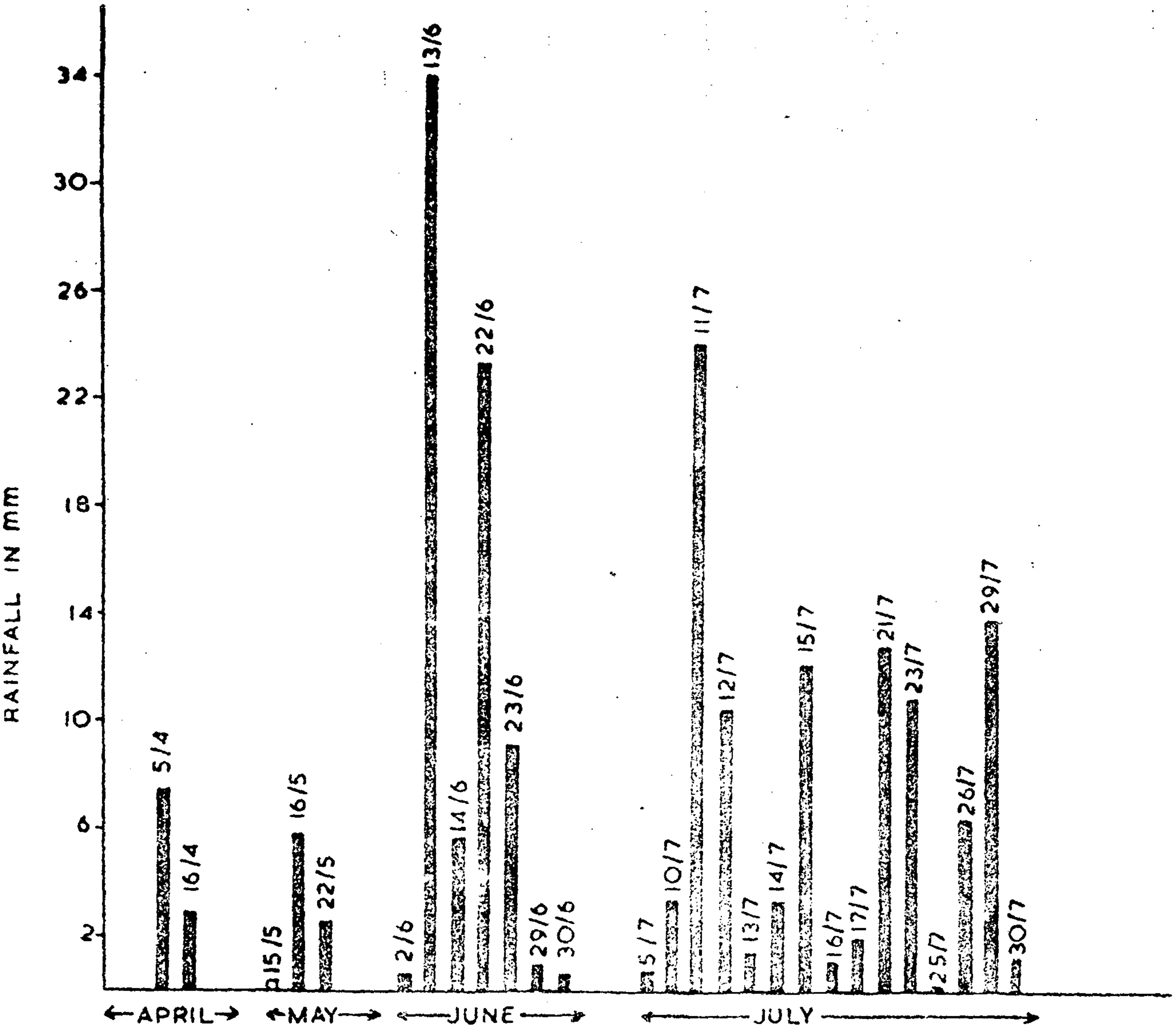
* Manual on water supply and treatment, second edition, Central Public Health and Environmental Engineering Organisation, Ministry of Works and Housing, New Delhi, 1976.

@ International Standards for drinking water, WHO, Geneva, 1971.



G.6 RAINFALL DATA FOR VARIOUS MONTHS IN 1979 AS OBTAINED FROM INDIAN DAILY WEATHER REPORT

APPENDIX . 2 MPN INDEX* PER 100 ML SAMPLE WHEN FIVE, 10 ML, 1 ML AND 0.1 ML REPLICATE PORTIONS OF EACH DILUTION ARE USED.

Positive in																							
10	1	0.1	MPN	10	1	0.1	MPN	10	1	0.1	MPN	10	1	0.1	MPN	10	1	0.1	MPN	10	1	0.1	MPN
0	0	0	2	1	0	0	2	2	0	0	5	3	0	0	8	4	0	0	13	5	0	0	23
0	0	1	2	1	0	1	4	2	0	1	7	3	0	1	11	4	0	1	17	5	0	1	31
0	0	2	4	1	0	2	6	2	0	2	9	3	0	2	13	4	0	2	21	5	0	2	43
0	0	3	5	1	0	3	8	2	0	3	12	3	0	3	16	4	0	3	25	5	0	3	58
0	0	4	7	1	0	4	10	2	0	4	14	3	0	4	20	4	0	4	30	5	0	4	76
0	0	5	9	1	0	5	12	2	0	5	16	3	0	5	23	4	0	5	36	5	0	5	95
0	1	0	2	1	1	0	4	2	1	0	7	3	1	0	11	4	1	0	17	5	1	0	33
0	1	1	4	1	1	1	6	2	1	1	9	3	1	1	14	4	1	1	21	5	1	1	46
0	1	2	6	1	1	2	8	2	1	2	12	3	1	2	17	4	1	2	26	5	1	2	64
0	1	3	7	1	1	3	10	2	1	3	14	3	1	3	20	4	1	3	31	5	1	3	84
0	1	4	9	1	1	4	12	2	1	4	17	3	1	4	23	4	1	4	36	5	1	4	110
0	1	5	11	1	1	5	14	2	1	5	19	3	1	5	27	4	1	5	42	5	1	5	130
0	2	0	4	1	2	0	6	2	2	0	9	3	2	0	14	4	2	0	22	5	2	0	49
0	2	1	6	1	2	1	8	2	2	1	12	3	2	1	17	4	2	1	26	5	2	1	70
0	2	2	7	1	2	2	10	2	2	2	14	3	2	2	20	4	2	2	32	5	2	2	95
0	2	3	9	1	2	3	12	2	2	3	17	3	2	3	24	4	2	3	38	5	2	3	120
0	2	4	11	1	2	4	15	2	2	4	19	3	2	4	27	4	2	4	44	5	2	4	150
0	2	5	13	1	2	5	17	2	2	5	22	3	2	5	31	4	2	5	50	5	2	5	180
0	3	0	6	1	3	0	8	2	3	0	12	3	3	0	17	4	3	0	27	5	3	0	79
0	3	1	8	1	3	1	10	2	3	1	14	3	3	1	21	4	3	1	33	5	3	1	110
0	3	2	9	1	3	2	13	2	3	2	17	3	3	2	24	4	3	2	39	5	3	2	140
0	3	3	11	1	3	3	15	2	3	3	20	3	3	3	28	4	3	3	45	5	3	3	180
0	3	4	13	1	3	4	17	2	3	4	22	3	3	4	31	4	3	4	52	5	3	4	210
0	3	5	15	1	3	5	19	2	3	5	25	3	3	5	35	4	3	5	59	5	3	5	250
0	4	0	8	1	4	0	11	2	4	0	15	3	4	0	21	4	4	0	34	5	4	0	130
0	4	1	9	1	4	1	13	2	4	1	17	3	4	1	24	4	4	1	40	5	4	1	170
0	4	2	11	1	4	2	15	2	4	2	20	3	4	2	28	4	4	2	47	5	4	2	220
0	4	3	13	1	4	3	17	2	4	3	23	3	4	3	32	4	4	3	54	5	4	3	280
0	4	4	15	1	4	4	19	2	4	4	25	3	4	4	36	4	4	4	62	5	4	4	350
0	4	5	17	1	4	5	27	2	4	5	28	3	4	5	40	4	4	5	69	5	4	5	430
0	5	0	9	1	5	0	13	2	5	0	17	3	5	0	25	4	5	0	41	5	5	0	240
0	5	1	11	1	5	1	15	2	5	1	20	3	5	1	29	4	5	1	48	5	5	1	350
0	5	2	13	1	5	2	17	2	5	2	23	3	5	2	32	4	5	2	56	5	5	2	540
0	5	3	15	1	5	3	19	2	5	3	26	33	5	3	37	4	5	3	64	5	5	3	920
0	5	4	17	1	5	4	22	2	5	4	29	3	5	4	41	4	5	4	72	5	5	4	1600
0	5	5	19	1	5	5	24	2	5	5	32	3	5	5	45	4	5	5	81	5	5	5	

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* APHA, 1971 Standard Methods for the Examination of Water and Wastewater, 13th Edition, 662-677